

Managing respirable dust hazards in coal-fired power stations

Code of Practice

2023

WHSQ

Workplace Health and Safety Queensland
worksafe.qld.gov.au



This Queensland code of practice has been approved by the Minister for Education, Minister for Industrial Relations and Minister for Racing under section 274 of the *Work Health and Safety Act 2011*.

The code commences on 3 December 2023.

PN12949



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Foreword

The Managing respirable dust hazards in coal-fired power stations Code of Practice 2023 is an approved code of practice under section 274 of the *Work Health and Safety Act 2011* (WHS Act).

An approved code of practice is a practical guide to achieving the standards of health, safety and welfare required under the WHS Act and the Work Health and Safety Regulation 2011 (WHS Regulation).

Under section 26A of the WHS Act, a person conducting a business or undertaking (PCBU) must:

- comply with an approved code of practice; or
- manage hazards and risks arising from the work carried out as part of the business or undertaking in a way that is different to the code but provides an equivalent or higher standard of work health and safety than the standard required in the code.

A code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice would achieve compliance with the health and safety duties in the WHS Act, in relation to the subject matter of the code. Like regulations, codes of practice deal with particular issues and do not cover all hazards or risks which may arise. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings under the WHS Act and WHS Regulation. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

An inspector may refer to an approved code of practice when issuing an improvement notice. This may include issuing an improvement notice for failure to comply with a code of practice where equivalent or higher standards of work health and safety have not been demonstrated.

Code terminology

This code includes references to the legal requirements under the WHS Act and WHS Regulation. These references are not exhaustive and are included for convenience only. They should not be relied on in place of the full text of the WHS Act or the WHS Regulation.

The words '**must**', '**requires**' or '**mandatory**' indicate that a legal requirement exists that must be complied with.

The word '**should**' is used in this code to identify the standard required in this code. PCBUs can only manage the identified hazard or risk in a different way if doing so provides an equivalent or higher standard of work health and safety.

The word '**may**' is used to identify an optional course of action.

Scope and application

This code provides practical guidance to PCBUs on how to comply with their health and safety duties in relation to the management of respirable dust hazards at coal-fired power stations.

1. Introduction

Workers in coal-fired power stations engage in a range of work tasks or processes which may involve handling or exposure to respirable dust, including coal dust or coal fly ash. The combustion process, in addition to producing steam for power generation, also produces coal fly ash and bottom ash, collectively known as “coal ash”, as a waste product.

This code applies to all respirable dusts in coal-fired power stations for which AS2985¹ applies and includes:

- coal dust and ash (containing variable percentages of respirable crystalline silica)
- respirable crystalline silica.

Although a respirable dust, this code does not apply to asbestos².

However, there are other (inhalable³) dusts likely to be encountered and for which the risks of health effect from exposure must also be controlled. These include:

- abrasive blasting dusts such as ilmenite and garnet
- wood dusts
- welding fumes
- synthetic man-made mineral fibres (e.g. glass wool, rock wool and ceramic fibres)
- toxic dusts (e.g. lead)

Most dust clouds contain particles of widely varying sizes. Hazardous dust is not always visible. The larger particles that can be breathed in are called inhalable or inspirable dust particles. *Inhalable* dust particles are visible to the naked eye and are deposited in the nose, throat and upper respiratory tract. *Respirable* dust contains dust particles so small they are invisible to the naked eye and reach deep into the lungs.

Different types of dust particles have different health effects. For example, respirable crystalline silica dust causes fibrosis and scarring of the lungs, and inhalable lead dust can damage the central nervous system. Many occupational diseases usually result from many years of exposure to dust, and it may take years or decades before the disease becomes noticeable. In some cases, these diseases (such as acute silicosis) may manifest in a shorter period due to extremely high dust exposures.

The potential health effects of some common dusts in coal-fired power stations are summarised below:

Health effect	Dust particle content
Pneumoconiosis (e.g. coal workers' pneumoconiosis or 'black lung') and chronic obstructive pulmonary disease (COPD) such as bronchitis and emphysema	Coal dust, coal fly ash
Lung scarring and fibrosis (e.g. silicosis)	Asbestos, quartz (respirable crystalline silica)

¹ Australian Standard 2985-2009 Workplace atmospheres – Method for sampling and gravimetric determination of respirable dust.

² Asbestos is regulated under the Work Health and Safety Regulation 2011 and two separate codes of practice – How to safely remove asbestos Code of Practice 2021 and How to manage and control asbestos in the workplace Code of Practice 2021.

³ Sample methods, equipment and analytical procedures for inhalable dusts is different to respirable dusts.

Systemic toxic effects caused by absorption into the blood	Lead, manganese, cadmium, zinc
Allergic and hypersensitivity reactions	Certain woods, organic and inorganic chemicals
Cancer	Chromates, asbestos, quartz (respirable crystalline silica)
Irritation of the mucous membranes of the nose and throat	Acid, alkali, other irritating particles

It is important to note that dust types can vary from site to site particularly in the areas of coal feedstock.

Once respirable dust particles enter the lower lungs, it becomes more difficult for the respiratory system to clear that dust. This means exposure to respirable dust and protecting the respiratory health of workers is an important part of the risk management process at a coal-fired power station.

What workplace exposure standards apply to respirable dust at coal-fired power stations?

A duty holder must ensure that no person at the workplace is exposed to a substance (e.g. coal dust or respirable crystalline silica) in an airborne concentration that exceeds the exposure standard (see section 3 of this code, Identifying respirable dust hazards) for the substance. Where workers have a working day longer than eight hours or work more than 40 hours a week, the PCBU must determine how the workplace exposure standard needs to be adjusted to compensate for the greater exposure during the longer work shift, and decreased recovery time between shifts. Further details on adjusting the exposure standard are detailed in section 3 of this code, Identifying respirable dust hazards.

Exposure standards represent airborne concentrations of individual chemical substances in a worker's breathing zone which, according to current knowledge, should neither cause adverse health effects nor undue discomfort to nearly all workers. However, they do not represent a fine line between "safe" and "unsafe" airborne concentrations. Instead they are best used to assess the quality of the working environment and indicate where appropriate control measures are required. The WHS Act places a duty on a PCBU to ensure exposure to respirable dust is controlled to as low as reasonably practicable and not simply to below the exposure standard.

Other hazards at coal-fired power stations?

Even if the dust is not at harmful levels or sizes that impact the lung (i.e. inhalable dust), it can increase the risk of physical injury because of the reduced visibility and irritation to the eyes and throat. Other physical risks associated with excessive dust include:

- obscuring signs and instruments
- abrasive damage to equipment
- reducing light emission from light fittings
- in extreme cases, explosions from the ignition of combustible dusts (i.e. coal).

There are a number of other hazards at coal-fired power stations which are outside the scope of this code of practice. Other common hazards include falls from heights, noise, asbestos and manual tasks and you should refer to the relevant codes of practice for further information. These are available at worksafe.qld.gov.au.

1.1 Who has health and safety duties in relation to respirable coal dust?

A person conducting a business or undertaking (PCBU) has the primary duty to ensure, so far as is reasonably practicable, workers and other people are not exposed to health and safety risks arising from the business or undertaking.

This duty requires the person to manage risks by eliminating health and safety risks so far as is reasonably practicable, and if it is not reasonably practicable to eliminate the risks, by minimising those risks so far as is reasonably practicable.

Designers, manufacturers, suppliers and importers of plant or structures, must ensure, so far as is reasonably practicable, the plant or structure is without risks to health and safety.

People installing, constructing or commissioning plant or structures must ensure, so far as is reasonably practicable, all workplace activity relating to the plant or structure including its installation, use, decommissioning or dismantling is without risks to health or safety.

Officers, such as company directors, have a duty to exercise due diligence to ensure the business or undertaking complies with the WHS Act and WHS Regulation. This includes taking reasonable steps to ensure the business or undertaking has and uses appropriate resources and processes to eliminate or minimise risks from respirable dust hazards.

Workers and other people at the workplace must take reasonable care for their own health and safety, co-operate with reasonable policies, procedures and instructions and not adversely affect other people's health and safety.

1.2 What is involved in managing risks associated with respirable dust at a power station?

WHS Regulation section 34-38 (summary): To manage risk, a PCBU must:

- identify reasonably foreseeable hazards that could give rise to risks to health and safety
- eliminate risks to health and safety so far as is reasonably practicable
- if it is not reasonably practicable to eliminate risks to health and safety – minimise those risks so far as is reasonably practicable by implementing risk control measures according to the hierarchy of control in WHS Regulation section 36
- ensure the control measure is, and is maintained so that it remains, effective, and
- review and as necessary revise control measures implemented to maintain, so far as is reasonably practicable, a work environment that is without risks to health or safety.

To properly manage risks, a person must:

- identify hazards – find out what caused or can cause the exposure
- assess risks that may result because of the hazards – understand the nature of the exposure that could be caused by the hazard, how serious the exposure could be and the likelihood of it happening

- implement control measures to eliminate, or minimise the level of the risks, and
- monitor and review the effectiveness of the measures.

Guidance on the general risk management process is available in the [How to manage work health and safety risks Code of Practice](#).

2. Consultation

2.1 Consulting workers

WHS Act section 47(1): The person conducting a business or undertaking must, so far as is reasonably practicable, consult with workers who carry out work for the business or undertaking who are, or are likely to be, directly affected by a matter relating to work health or safety.

WHS Act section 48(2): If the workers are represented by a health and safety representative, the consultation must involve that representative.

Consultation involves sharing of information, giving workers a reasonable opportunity to express views and taking those views into account before making decisions on health and safety matters.

Consultation with workers and their health and safety representatives is required at each step of the risk management process. In many cases, decisions about work are made before engaging workers so it may not always be possible to consult with workers in these early stages. However, it is important to consult with workers as work progresses. By drawing on the experience, knowledge and ideas of workers this approach is more likely to identify hazards and choose effective control measures.

A PCBU should encourage workers to report hazards and health and safety problems immediately so the risks can be managed before an incident occurs. A PCBU must consult workers when proposing any changes to the work that may affect their health and safety.

In the context of the management of respirable dust hazards within a coal-fired power station, consultation with workers should occur on, but is not limited to, the following:

- identifying respirable dust hazards
- during the development, modification, or implementation of the respirable dust monitoring program (air monitoring program)
- on air monitoring results generally, including any exceedances and subsequent investigations
- during the development, modification, or implementation of the dust control strategy
- during the development of the health monitoring program including in relation to the selection of the registered medical practitioner for health monitoring purposes.

2.2 Consulting, cooperating and coordinating activities with other duty holders

WHS Act section 46: If more than one person has a duty in relation to the same matter, each person with the duty must, so far as is reasonably practicable, consult, cooperate and coordinate activities with all other persons who have a duty in relation to the same matter.

A PCBU may share responsibility for a health and safety matter with other business operators who are involved in the same activities or who share the same workplace. In these situations, duty holders must, so far as is reasonably practicable, exchange information to

find out who is doing what and work together in a cooperative and coordinated way so that all risks are eliminated or minimised as far as reasonably practicable.

For example, the health monitoring for workers, including contract cleaners who perform major overhaul work, is a shared duty between the PCBU (i.e. the power station and the contractors) to ensure health monitoring is provided.

Further guidance on consultation is available in the [Work health and safety consultation, co-operation and co-ordination Code of Practice](#).

3. Identifying respirable dust hazards

The first step in managing risks associated with exposure to respirable dust is to identify the dust hazards that are generated. Potential respirable dust hazards may be identified in a number of different ways, including:

- conducting a risk assessment of work processes and the work environment
- conducting a walk-through assessment of the workplace
- undertaking air monitoring at the workplace
- observing the work and talking to workers about how work is carried out
- inspecting the plant and equipment that is used as part of electricity generation
- reviewing incident reports.

Respirable dusts can be generated and released into the atmosphere during coal-fired power plant operations in a number of ways including:

- disturbing coal by mechanical means such as delivery of and transporting coal to the site (e.g. when coal is dumped into the hopper)
- moving coal around the site (rail, trucks or load shifting equipment or by conveyor belts with issues such as coal belts with holes, conveyor belt breakages)
- storage of coal onsite such as wind causing coal dust to be released from the stockpile or from local traffic around the stockpile area
- accumulated dust being 'raised' from the ground or other surfaces by moving vehicles and people
- lack of adequate equipment inspection and maintenance activities that prevent dust build up, including delays in addressing system defects and leaks
- inadequate cleaning regimes that allow excessive build-up of coal around equipment and structures such as belt systems, conveyors and surrounding work areas or from spillages
- during maintenance activities in fly ash collection areas including fabric filters, electrostatic precipitators and dust hoppers
- during maintenance activities in coal pulverisers and milling/crushing areas
- cleaning activities during overhaul work where fly ash and coal dust accumulates (boiler furnaces, flue gas duct work and burner fronts)
- handling and transportation operations of fly ash (loading of fly ash for transportation).

All possible sources of the generation of dust in the power station must be identified and control measures implemented to eliminate or minimise the generation of airborne dust at the source, so far as is reasonably practicable.

What specific tasks and processes are likely to expose workers to respirable dust above the exposure standard?

Studies⁴ of coal-fired power station workers have concluded that day-to-day operational exposures are likely to be low, however there are some activities that are associated with airborne concentrations of respirable dust likely to cause exposure above exposure standards such as:

- when coal is broken, crushed or milled as part of processing into the fuel system
- maintenance and cleaning activities (e.g. inside boilers, economisers, flue conveyance ducts, baghouses, electrostatic precipitators and ash silos)
- the handling and transport of coal fly ash
- during major overhaul work on power plant systems.

⁴ J. Hicks and J. Yager, "Airborne Crystalline Silica Concentrations at Coal-Fired Power Plants Associated with Coal Fly Ash," *Journal of Occupational and Environmental Hygiene*, no. 3, pp. 448-455, August 2006 and D. Ward, "Measurement of Exposure Levels to Airborne Pulverised Fuel Ash (PFA) in Power Stations," *Annals of Occupational Hygiene*, vol. 27, no. 2, p. 227, 1983.

Other tasks likely to expose workers to respirable dust can also occur when equipment with ash and/or coal dust build-up is repaired without removing the excess dust.

Power plant workers at potential risk of exposure to respirable dust

There are various roles undertaken by workers at power plants that may involve exposure to respirable dust. Workers at potential risk include:

- operations workers
- mechanical maintenance workers
- electrical maintenance workers
- non-trades maintenance workers (power workers and utility workers such as greasers, scaffolders, riggers)
- industrial cleaners
- overhaul workers
- technical staff (engineers, technical officers)
- coal unloading and handling plant personnel (rail, conveyor, stockpile management)
- fly ash transport workers
- bottom (furnace) ash transport workers
- ash dam/mine void/cenosphere harvesting and storage workers.

The roles above are generic and could be workers or contractors depending on the operation. This list is not exhaustive and other roles with potential exposure should be considered as part task planning.

3.1 Exposure standards

WHS Regulation section 49: A person conducting a business or undertaking at a workplace must ensure that no person at the workplace is exposed to a substance or mixture in an airborne concentration that exceeds the exposure standard for the substance or mixture.

Exposure standards represent airborne concentrations of a particular substance such as coal dust that must not be exceeded.

There are three types of exposure standards:

- Eight-hour time-weighted average (TWA) is an eight-hour time-weighted average exposure standard for the average airborne concentration of a particular substance permitted over an eight-hour working day in a five-day working week.
- Peak limitation – a maximum or peak airborne concentration of a particular substance determined over the shortest analytically practicable period of time which does not exceed 15 minutes.
- Short term exposure limit – the time-weighted maximum average airborne concentration of a particular substance permitted over a 15 minute period.

Coal dust and respirable crystalline silica have an eight-hour TWA and no peak limitation or short-term exposure limit.

The exposure standards are listed in the Workplace Exposure Standards for Airborne Contaminants and the Hazardous Chemicals Information System (HCIS) both available on the Safe Work Australia website. The HCIS database contains additional information and guidance for many substances.

As many of the respirable dusts likely to be encountered as part of work tasks or processes as part of power generation have an exposure standard, duty holders must ensure that

workers are not exposed to levels that exceed the workplace exposure standard. Table 1 below outlines certain exposure standards that may be relevant to the types of respirable dusts encountered at a coal-fired power station.

Table 1: Workplace exposure standards

Contaminant	Exposure standard (8 hour TWA)
Coal dust (containing <5% crystalline silica)	1.5mg/m ³
Respirable crystalline silica	0.05mg/m ³

Adjustment of exposure standards for extended work shifts

Some exposure standards need to be adjusted to account for greater exposure that occurs during extended work shifts and to comply with the WHS Regulations.

An eight-hour TWA exposure standard is based on exposure that occurs in an eight-hour working day, five-day working week. Where workers have a working day longer than eight hours, a working week longer than 40 hours or work shift rotations in excess of either eight hours a day or 40 hours a week, the TWA exposure standard may need to be adjusted to compensate for the greater exposure during the longer work shift and the decreased recovery time between shifts.

Several mathematical models can be used for adjusting exposure standards for extended work shifts. These models include the 'Brief and Scala Model'⁵, the US 'Occupational Safety and Health Administration Model'⁶, the 'Pharmacokinetic Model' of Hickey and Reist⁷, and the Quebec Model⁸. All models provide valid methods for adjusting exposure standards. The main difference is the degree of conservatism. Selection of a model will depend on the information available and the expertise of the person applying it.

The use of adjustment models other than the Brief and Scala Model should only be done by an appropriately qualified health and safety professional as the use of other models requires a sound understanding of the toxicology and pharmacokinetics of the substance as well as the rationale for setting the exposure standard.

It is important to note that eight-hour TWA exposure standards must not be adjusted upwards for shorter exposure periods or work shifts.

It is preferable to keep exposure limits continually below the eight-hour TWA exposure standard. However, during periods of continuous daily exposure to an airborne contaminant, the eight-hour TWA exposure standard allows short term excursions above the exposure standard provided they are compensated for by extended periods of exposure below the standard during the working day. In practice, the actual concentration of an airborne contaminant arising from a particular process may fluctuate significantly with time. Even where the TWA exposure standard is not exceeded, excursions over the eight-hour TWA exposure standard should be controlled.

⁵ Brief R, Scala R. Occupational Exposure Limits for Novel Work Schedules, American Industrial Hygiene Association Journal. 36:467-469, 1975.

⁶ Paustenbach D. Occupational Exposure Limits, Pharmacokinetics and Unusual Work Shifts. Patty's Industrial Hygiene and Toxicology, Vol III, Ed Harris, R. L., New York, John Wiley & Sons, 11-277, 2000.

⁷ Hickey J, Reist P. Application of Occupational Exposure Limits to Unusual Work Schedules. American Industrial Hygiene Association Journal. 38:613-621, 1977.

⁸ Institut de recherche Robert-Sauvé en santé et en sécurité du travail, (IRSST), Guide for the adjustment of Permissible Exposure Values (PEVs) for unusual Work Schedules, 3rd Edition, IRSST, Montréal, 2008.

A process is not considered to be under reasonable control if short term exposures exceed three times the TWA exposure standard for more than a total of 30 minutes per eight-hour working day, or if a single short-term value exceeds five times the eight-hour TWA exposure standard.

Further guidance on interpreting exposure standards is available at www.safeworkaustralia.gov.au.

4. Assessing the risks from respirable dust exposure

WHS Regulation section 50: A person conducting a business or undertaking at a workplace must ensure that air monitoring is carried out to determine the airborne concentration of a substance or mixture at the workplace to which an exposure standard applies if:

- a) the person is not certain on reasonable grounds whether or not the airborne concentration of the substance or mixture at the workplace exceeds the relevant exposure standard; or
- b) monitoring is necessary to determine whether there is a risk to health.

The results of air monitoring must be recorded and kept for 30 years after the date the record is made.

There are a number of factors that affect the degree of risk associated with dust produced in coal-fired power plant operations. These factors include:

- the concentration of airborne dust in the breathing zone of the worker
- the size of the dust particles generated (whether dust particles are inhalable or respirable)
- the duration of exposure
- the type of dust and its biological effect.

You must also identify any reasonably foreseeable situations where dust could spread to other workplaces or the environment.

In the context of this code, air monitoring involves the sampling of airborne respirable dust in the workplace to obtain an estimate of workers' potential exposure. Air monitoring is used:

- when there is uncertainty about the level of exposure
- to indicate whether the exposure standards are being exceeded or approached
- to test the effectiveness of the control measures.

Air monitoring in this code is referred to as respirable dust monitoring.

4.1 Respirable dust monitoring program

The PCBU should ensure:

- the power station has a respirable dust monitoring program (this usually forms part of the power station's health and safety management system)
- the respirable dust monitoring plan has been developed by a competent person
- respirable dust sampling is only conducted by a competent person
- an investigation is conducted when a personal sample exceeds the workplace exposure standard
- the respirable dust monitoring program is reviewed by a competent person at regular intervals
- sampling equipment is calibrated and maintained.

The respirable dust monitoring program should be developed in consultation with workers and their health and safety representatives.

Competency to develop and review a respirable dust monitoring program

Only a person who has a recognised competency as a certified occupational hygienist, or an equivalent competency under an international certification scheme (e.g. certified industrial hygienist), can review the adequacy of and endorse the power station's respirable dust monitoring program, and specifically:

- establish the similar exposure groups
- develop a respirable dust sampling plan that is representative of worker numbers, workers' shift work, tasks performed and conditions at the power station
- estimate exposure of similar exposure groups using descriptive statistics.

Competency to conduct respirable dust sampling

Air monitoring should be carried out by a person such as an occupational hygiene technician with skills to carry out the monitoring according to standards and to interpret the results.

4.2 Minimum technical requirements

Establishing similar exposure groups (SEGs)

The PCBU should ensure that similar exposure groups (SEGs) are established for the power plant and, at a minimum, cover activities, workers and contractors in the following areas:

- Coal handling plant – the workplace areas and workplace activities associated with the function of receiving and stockpiling of coal onto site, and the transfer and conveying of that material to the facility in readiness for pulverising.
- Fuel plant – the workplace areas and workplace activities associated with the transfer and pulverising of coal from its stored state to being a pulverised fuel for use in the combustion chamber.
- Ash plant – the workplace areas and workplace activities associated with the capture, transfer, storage and disposal of power station bi-products.
- Auxiliary plant – the workplace areas and workplace activities associated with supporting the generation and transmission of electric power, other than coal and fuel handling plant. Areas might include chemical plant, water treatment, effluent management, air-conditioning, lifts and compressors.
- Power block unit – the workplace areas and workplace activities associated with maintaining the operational plant within the power unit block. The plant may include high-pressure boilers, valves, generators, and other equipment in the central heating and power plant.
- Major shutdowns – describes the phased outage management process within the Queensland generation industry, where major maintenance is conducted on an individual power unit.
- Operational personnel who work across multiple areas.

SEGs can generally be based on work or functional groups, but in some instances may be more specific due to particular exposure circumstances.

The PCBU should also consider whether other categories of SEGs specific to that worksite are required. These SEGs would include groups of workers with exposure profiles not common at all coal-fired power stations. In addition, the SEGs may need to be adapted to the specific circumstances of the site such as rosters, rotation of tasks and controls, or location such as proximity to coal stockpiles or coal delivery areas.

Sampling equipment

Equipment used to sample respirable dust should be subject to periodic calibration and maintenance, as per Australian Standard 2985 Workplace atmospheres – Method for sampling and gravimetric determination of respirable dust (AS 2985) and the manufacturer's recommendations. You must keep records of calibration and maintenance.

Types of sampling

Sampling is a process of conducting a measure or series of measures of the concentrations of airborne contaminants, such as respirable dust and respirable crystalline silica. Sampling should include the most appropriate type or mix of sampling based on advice of the occupational hygienist.

Types of sampling and applications include:

- Personal sampling
 - baseline monitoring – used to provide an initial estimate of exposure to enable future comparisons of air monitoring results
 - periodic monitoring – ongoing monitoring to ensure adequacy of exposure controls and to monitor the exposure of workers
 - investigative monitoring – follows instances where the exposure standard has been exceeded to determine if new or modified controls are adequate.
- Static and real-time sampling is aimed at:
 - investigating the source and/or causes of unacceptable personal exposure
 - assessing the efficiency of dust controls.

Personal sampling

Personal sampling is the process used to measure a worker's potential exposure to dust during the course of their usual shift activities (i.e. also including breaks). Personal sampling requires dust measurements to be collected from within the breathing zone of the worker and the samples analysed at a National Association of Testing Authorities (NATA) accredited laboratory. The results of personal sampling for groups of workers performing similar tasks or working in the same area can be combined and analysed using statistical tools to provide an estimate of exposure for the SEG.

- **Baseline monitoring** is conducted to establish an initial estimate of exposure for a new or modified process or activity, to enable comparison with exposure limits and identify areas requiring additional exposure control.
- **Periodic monitoring** commences when baseline monitoring is completed. Periodic monitoring provides information on the ongoing adequacy of exposure controls to ensure the exposure of workers remains compliant with relevant exposure standards, and the risk of adverse health effects to workers is at an acceptable level.

One of the drawbacks of personal dust monitoring is that it typically does not identify the source or cause of dust entering the worker's breathing zone or at what times during the shift specific exposure may have occurred.

Static sampling

Static (or fixed) sampling can be used to measure area-specific dust levels and identify sources and causes of dust generation, to enable dust control efforts to be focused and prioritised. Dust measures collected at static sampling points are not representative of actual worker exposure and should not be compared to an exposure standard. Static sampling is a valuable tool for assessing the effectiveness of process controls, for example, sampling before and after the implementation of controls so the effectiveness of those controls can be verified.

Place static sampling points close to sources of dust to assess the magnitude of dust levels. Location of static sampling points should be documented in sufficient detail so that measurements can be repeated.

Real-time sampling

Real-time sampling uses a direct-reading device to measure dust concentrations and can be used in a variety of ways, depending on the functionality of the direct-reading device. Real-time devices can be used in conjunction with gravimetric sampling to detect changes in instantaneous dust concentrations, or even peaks in dust concentrations if the device has a logging mode. Real-time devices can also be used to give an indicative time-weighted average if collected in the breathing zone of the worker and the duration of sampling is representative of normal shift activities. It is important to note that real-time sampling cannot be used to assess compliance with workplace exposure standards. It can provide an indication of the effectiveness of control measures in place. This means real-time sampling is not necessary for the full shift length.

The benefits of obtaining instantaneous dust concentrations, when compared to the time delay for gravimetric analysis, are that multiple measurements can be quickly made to investigate the source or cause of dust exposure, and dust controls and positioning of workers can be adjusted in real time.

There are limitations of real-time sampling devices. The most important limitation relates to the way direct-reading instruments calculate the mass of particles being sampled. For example, a laser photometer (a common direct-reading instrument) counts the number of aerosol particles in a sample of air. The mass of the aerosol particles is then calculated based on the properties of the calibration aerosol and converted to a dust concentration measurement based on the volume of the air sampled.

Another form of direct-reading instrument is the tapered element oscillating microbalance (TEOM) which is commonly used technology for personal dust monitors. The mass of aerosol particles is calculated by monitoring the frequency changes in a vibrating tapered element. This mass is converted to a dust concentration measurement based on the volume of air sampled.

The laser photometer and the TEOM do not determine mass gravimetrically in accordance with AS 2985. Measurements from these devices cannot be used to assess compliance with workplace exposure standards and are indicative only

Standard for collecting respirable dust samples

Respirable dust sampling at a power station should be carried out in accordance with AS 2985 Workplace atmospheres – Method for sampling and gravimetric determination of respirable dust (Standards Australia).

Standard for analysing respirable dust samples

All samples collected for the purpose of personal exposure assessment should be analysed in accordance with AS 2985.

Laboratories performing analysis of respirable dust samples must be certified to ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories for the gravimetric determination of respirable dust and for the analysis of respirable crystalline silica.

4.3 Establishing a personal exposure monitoring program

Baseline monitoring

Baseline monitoring using SEGs should be conducted to establish the initial estimate of exposure for the SEG and to define periodic monitoring requirements. Table 2 can be used for guidance on the sampling numbers to establish a baseline of exposure.

Table 2: Minimum sample numbers for baseline monitoring (source: NIOSH occupational exposure sampling strategy manual)

No of workers in similar exposure groups (N)	Samples to be taken (n)
<8	n=N*
8	7
9	8
10	9
11-12	10
13-14	11
15-17	12
18-20	13
21-24	14
25-29	15
*Minimum number of samples to be taken where N<8 is 6 samples	

Following the collection of the minimum number of required samples, descriptive and inferential statistics should be used to analyse the data and compare with the relevant workplace exposure standards. The minimum number of samples to be taken where N<8 is 6. By using the minimum number of samples specified in Table 2, there can be 90 per cent confidence that at least one worker selected at random from the SEG will be in the highest 10 per cent of all exposure in that SEG.

Periodic monitoring

Periodic monitoring requirements for each SEG should be risk based and are dependent on the baseline monitoring estimate of exposure. The number of samples required as part of periodic monitoring can be determined using Table 3. Consideration of all existing data is also valuable in determining ongoing monitoring program requirements and may justify the need to set sampling targets above those in Table 3.

Table 3: Minimum sample numbers and frequency for periodic monitoring (source: adopted from the Grantham, D and Firth, I. 2014. Occupational hygiene monitoring and compliance strategies, Australian Institute of Occupational Hygienists, Tullamarine)

Ratio of exposure to workplace exposure standard (R)	No. of crew/shifts to be monitored per 10 workers
>0.75	1 per month
0.5-0.75	1 per quarter
0.1-<0.5	1 per year
<0.1	Not required*

*SEG monitoring can still be performed with an exposure to exposure standard ratio of <0.1.

The model is suitable for SEGs that have a small population, but it is not suitable for large SEGs. An upper limit of 22 samples for SEGs can be applied for a periodic monitoring program. This limit does not preclude the collection of a greater number of samples if desired and is a decision that should be guided by the statistical analysis of the data. An upper limit of 22 samples is consistent with the sampling targets that would be specified for a baseline assessment of a SEG as defined in Table 2.

Where:
$$R = \frac{\text{Average exposure (geometric mean of baseline/monitoring program data)}}{\text{exposure standard}}$$

Example: the measurement of a Boiler Shutdown scaffolder SEG baseline estimate of exposure has identified an average exposure to respirable crystalline silica of 0.025mg/m³. The SEG is made up of four crews/shifts of five workers, and an exposure limit of 0.05 mg/m³ applies. Given that the value for R is in the range 0.5–0.75 (0.025 ÷ 0.05 = 0.5), and the total population of the SEG is 20 workers (4 × 5 = 20), the ongoing sample program will be two crews per shift per quarter (20 ÷ 10 = 2).

4.4 Additional personal sampling requirements

Sample duration

All personal samples collected to estimate exposure should be collected in the breathing zone of the selected worker and performed over a period representative of normal shift activities. Full shift sampling is preferred but, as a minimum, the sample period should be at least 80 per cent of the shift length.

Random sampling

Personal sampling should be conducted to ensure workers, contractors, crews, dates, times, environmental and operating conditions are randomly selected.

Data collection

Records of sampling performed for respirable dust must be kept for 30 years and include:

- certificate of analysis for samples
- information contained in the tables presented in Appendix 2.

Void or invalid samples

Samples that do not meet the minimum sampling or quality requirements are void or invalid and cannot be used for estimating personal exposure. The reason for deciding a sample is void or invalid should be documented. Additionally, sampling should be collected for the relevant SEG to replace any void or invalid samples.

Under no circumstances can void or invalid samples be included in the SEG datasets and used to estimate exposure.

Estimating personal exposure

Following the collection of the minimum number of required samples, descriptive and inferential statistics should be generated to summarise the dataset and estimate personal exposure. See Appendix 1 for further details.

An industrial hygiene statistical analysis software tool should be used to generate descriptive and inferential statistics, for example, the free industrial hygiene statistical analysis software tool, EASC-IHSTAT-V235, which can be downloaded on the American Industrial Hygiene Association's (AIHA) website www.aiha.org.

4.5 Similar exposure group (SEG) exposure assessment

Comparing SEG exposure data with exposure standards for respirable dusts should be performed using the 95 per cent upper confidence limit (UCL) of the mean. A SEG is conforming to section 49 of the WHS Regulation 2011 if the 95 per cent UCL of exposure of the group is equal to or below the relevant eight hour equivalent exposure standard.

For the purposes of this code, where the 95 per cent UCL of any SEG exceeds 50 per cent of the exposure standard this is considered to be 'significant risk' and is a trigger to:

- undertake an ongoing review of exposure controls and their effectiveness
- undertake health monitoring.

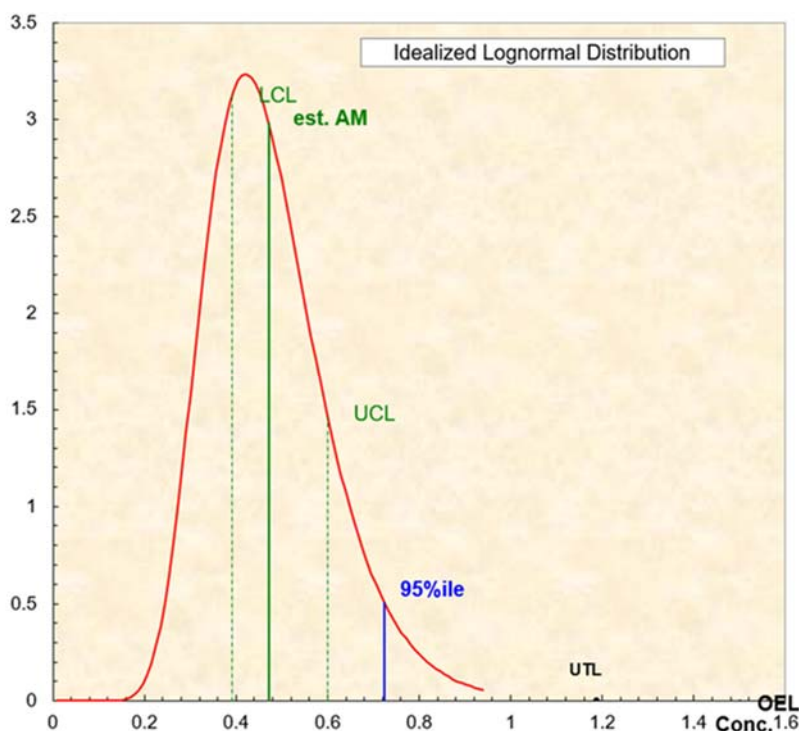


Figure 1: Respirable coal dust

In Figure 1, the workplace exposure standard (WES) is 1.5 mg/m³ for respirable coal dust. The 95 per cent UCL of 0.6 mg/m³ of the SEG is well below 50 per cent of the WES. The average exposure of the group is 0.47 mg/m³. Current controls should be maintained.

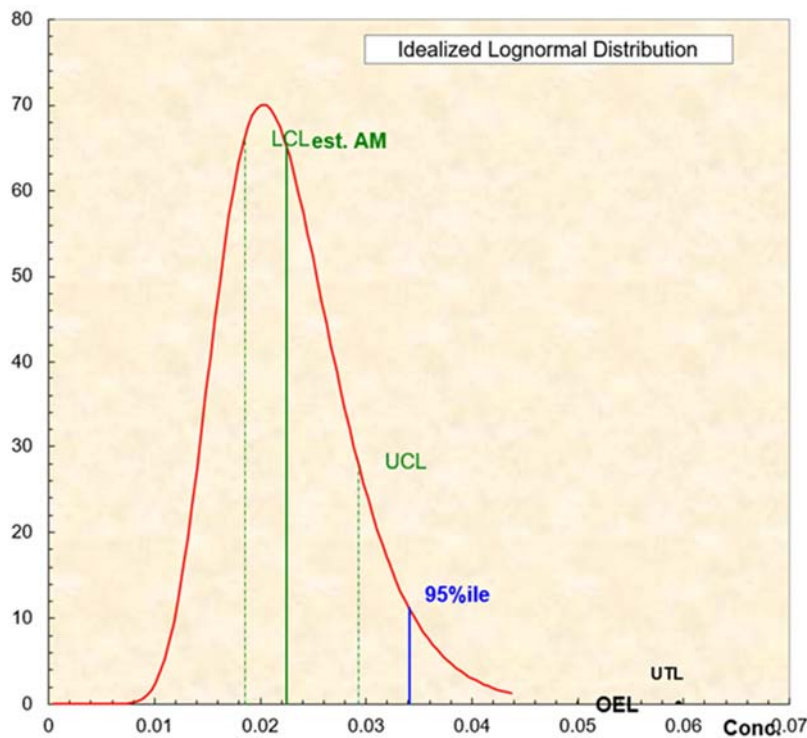


Figure 2: Respirable crystalline silica

In Figure 2, the WES is 0.05 mg/m³ for respirable crystalline silica. The 95 per cent UCL of 0.029mg/m³ of the SEG is above 50 per cent of the WES. The average exposure of the group is 0.022 mg/m³. A review of exposure controls followed by improvement of controls, plus health monitoring should be done.

If ongoing exposure data remains representative of the SEG exposure conditions, the data should be added to and analysed with the existing SEG data.

SEG data should be reviewed at least annually, but more frequently if dictated by the sampling schedule, to determine if there are any differences between previous periods and identify any upward or downward trends in exposure due to reduced or increased control effectiveness.

Single sample exposure result

A single air monitoring sample result that exceeds the relevant eight-hour equivalent exposure standard is a trigger for investigation and review of control measures.

Further information about investigating exposure exceedances is provided in section 4 Assessing the risks from respirable dust exposure in relation to reviewing control measures.

4.6 Reporting

Reporting of single sample exceedance results (SSER)

Informing the worker

Where a single air monitoring sample exceeds the exposure standard, and it is likely the worker has been exposed to respirable dust that exceeds the exposure standard, the PCBU should make contact with the worker. Where the worker is a contract worker, the PCBU employing that worker is to provide information about the analytical results, the process for consideration and requirements for review.

Informing the health and safety representative

In addition, the PCBU should share findings of the single sample exceedance result (SSER) with the health and safety representative for the relevant workgroup.

Informing the health and safety committee

If a health and safety committee is established, the PCBU should inform the committee and table the summary of the analytical results, including:

- the nature of the sample results
- details of results where a SSER occurred (including details of existing controls being used and if respirable protective equipment (RPE) was in use, the type of RPE)
- the relevant work group where a SSER occurred
- any interim corrective actions, including
 - what is being considered
 - the process for consideration
 - how actions will be determined.

Following the investigation and a decision making process relating to further action, details will be re-addressed as part of the committee standing agenda items. Where a single air monitoring sample exceeds the workplace exposure standard, the points outlined above should be discussed with the worker prior to being tabled at the health and safety committee.

Informing the WHS Regulator

In addition, the PCBU should submit a summary of the analytical results to the WHS Regulator, including:

- the nature of the sample results
- details of results where a SSER occurred (including details of existing controls being used and if RPE was in use, the type of RPE)
- the relevant work group where a SSER occurred
- any interim corrective actions, including
 - what is being considered
 - the process for consideration
 - how actions will be determined.

This information should be submitted to the WHS Regulator in a SSER reporting form as presented in Appendix 3 and at worksafe.qld.gov.au. In addition, the WHS Regulator should be informed as soon as reasonably practicable following the investigation and the decision-making process relating to further action.

Reporting of respirable dust monitoring results generally

Full SEG summary reports are to be provided to all work groups, health and safety representatives and the health and safety committee with supporting contextual information to enable an understanding of the relative risk of the dust hazards.

In addition, relevant summary reports should be provided to other PCBUs where more than one person has a duty in relation to the same matter. For example, reports should be provided to contract cleaners who perform routine cleaning onsite to assist the PCBU who has a shared duty with the coal-fired power station for air monitoring and health monitoring.

4.7 Recordkeeping

Records of respirable dust monitoring completed (including records of sampling performed) must be kept (in hard copy or electronic form) for 30 years and made readily accessible to persons at the workplace who may have been exposed.

Records of personal sampling should include:

- the certificate of analysis for the samples
- the minimum data required to be collected by the person conducting sampling as outlined in Appendix 2.

In addition, the PCBU should ensure these records are made available at the workplace where the monitoring occurred for inspection by an inspector at any time. All results should be classified into the similar exposure groups outlined in this code.

5. Controlling respirable dust risks

WHS Regulation section 35: A duty holder, in managing risks to health and safety, must -

- a) eliminate risks to health and safety so far as is reasonably practicable; and
- b) if it is not reasonably practicable to eliminate risks to health and safety – minimise those risks so far as is reasonably practicable.

WHS Regulation section 36: If it is not reasonably practicable for a duty holder to eliminate risks to health and safety, the duty holder must minimise risks, so far as is reasonably practicable, by doing one or more of the following -

- a) substituting (wholly or partly) the hazard giving rise to the risk with something that gives rise to a lesser risk;
- b) isolating the hazard from any person exposed to it;
- c) implementing engineering controls.

If a risk then remains, the duty holder must minimise the remaining risk, so far as is reasonably practicable, by implementing administrative controls.

If a risk then remains, the duty holder must minimise the remaining risk, so far as is reasonably practicable, by ensuring the provision and use of suitable personal protective equipment.

5.1 Dust control strategy

The PCBU should develop a dust control strategy which covers the following matters:

- Identify sources of dust generation.
- Develop and implement dust controls for each activity.
- Follow the hierarchy of controls to manage the risk of dust exposure – the primary aim should be to limit dust exposure via the control of excessive dust emissions rather than relying on respiratory protective equipment which should be used as a secondary measure.
- Incorporate dust control measures into shift and daily routines and ensure these are documented and adequately resourced in short-term and long-term planning processes.
- Review the effectiveness of controls in a systematic way.
- Inspect, maintain and monitor controls and equipment (by an appropriately trained and competent person).

The PCBU should develop the dust control strategy in consultation with workers involved in carrying out the tasks and the relevant health and safety representative of the work group.

5.2 Elimination/substitution controls

New plant – when preparing specifications for the installation of new plant the following factors should be considered:

- The uncontrolled discharge of airborne dust from plant into the work environment is to be prevented or mitigated.
- Discharge of dust into working areas should be prevented by using dust suppression systems or dust extraction systems.
- Maintenance schedules include the inspection and repair of all seals from which dust may escape.

Existing plant – where dust emissions from plant occur, and it is likely that a worker will be exposed to respirable dust that exceeds 50 per cent of the exposure standard, the plant should be assessed to determine the practicality of modifying the plant to eliminate the cause of the problem. Where this is impractical or cannot be undertaken within a reasonable period, then secondary controls should be put in place to ensure exposure to a worker is kept below the prescribed workplace exposure standard.

The general design of plant aims to keep dusts enclosed which is integral to minimising exposure to workers and others. When a situation occurs where dust escapes from the closed system, or the system is required to be opened for access, processes need to be applied to address the nature of the escape and to mitigate the need for workers to be in the location until controls are implemented.

Engineering controls

Engineering controls are physical in nature, including mechanical devices or processes that eliminate or minimise the generation of dust hazards. Priority should be given to controls that eliminate the dust hazard at the source, either through filtration or through the use of ventilation techniques.

Mechanical handling

Mechanical, automated and remotely controlled methods are often appropriate for the handling of potentially harmful substances in order to minimise the exposure of workers to respirable dust (e.g. covered conveyors).

Ventilation

Dilution ventilation aims to dilute the concentration of respirable dust and reduce the levels of contamination which reach workers by supplying a sufficient volume of clean air. This method is usually applicable to processes which can be operated in open air or with a skeleton structure and roof. Open structures can provide good natural ventilation, however require appropriate design to be effective (e.g. the effects of thermal air movements require specialist consideration). It is also important to note that dilution ventilation is not as effective as local exhaust ventilation for the control of respirable dust.

Respirable dust is more effectively controlled at its source by means of a local exhaust system. This system comprises:

- a hood which captures the contaminant at its point of generation
- a duct system with appropriate airflow
- an air cleaning system to prevent pollution of the general atmosphere
- an exhaust fan
- a stack or other means of dispersion of the decontaminated air to the atmosphere.

Dust suppression techniques

Wet methods of working, involving the use of a suitable liquid, usually water, can often be adopted in the control of respirable dust. Technical advice from those competent in the science of water behaviour in dust capture and spray (including droplet size and interactions with dust particle size) is required to achieve effective respirable dust management. Some key considerations in effective water design are to ensure that effective water application is within the pressure and flow capacity of the delivery system and ensure the ability to contain and manage the water generated.

Examples include:

- wet spraying, to suppress dust at the point of generation (e.g. at drop points on conveyors, stockpiles to prevent wind causing coal dust)
- adding surfactant (detergent) to dust suppression water
- using tools fitted with dust extraction or water attachments
- installing water applicators onto the machinery
- wetting ash settling ponds to prevent them from drying out and then cleaning out using machinery
- wetting spillages, conveyors and roadways.



Image 1. Primary dust suppression at coal unloading facility.

Sealants

Coal sealants offer coal-fired plants a way to protect large stockpiles of coal against moisture, oxidation and other forms of deterioration. Left unsealed, coal piles will suffer a loss of Btu (British thermal unit) value and burn less efficiently.

5.3 Isolation, segregation or enclosure of operations generating the dust

Isolation

Relevant isolation controls include:

- enclosed cabins with windows closed at all times
- fitting high efficiency air filtering systems (e.g. HEPA filters) to the intake and cabin recirculation air intake of front end loaders, excavators and other machinery
- keeping personnel vehicles dust sealed and pressurised.



Image 2. Coal plant backhoe with pressurised cabin.

Exclusion zones

There may be unique occasions when there is no alternative to use exclusion zones to protect workers and other persons in the vicinity from exposure to respirable dust.

The size of the exclusion zone should be determined after assessing the risk to all unprotected people. The prevailing conditions should be taken into account, for example, the exclusion zone may need to be extended down-wind.

An exclusion zone should be established and maintained to exclude workers and other people who are not wearing respiratory protective equipment (RPE). Warning signs should be located so that they are clearly visible before entering the area. Signs should warn that:

- there is a dust hazard present
- access to the area is restricted to authorised persons
- RPE should be worn in the exclusion zone.

Where an exclusion zone interferes with other activities at a workplace, other workers should only work within the exclusion zone after being provided with RPE.

5.4 Administrative controls

Housekeeping

Good housekeeping practices should be maintained in work areas. Dust and solid debris should not be allowed to accumulate and should be cleaned regularly.

Where processes involving dusts are carried out, the building and plant should be cleaned by a method that effectively removes accumulations of dust, but which does not in itself give rise to airborne dust. The careful design of new buildings or plant can facilitate cleaning, for example avoiding ledges and porous surfaces can make cleaning easier.

Plant should not be cleaned by brushing, compressed airline or any other method which disturbs the dust, such as dry sweeping, as once the dust has become airborne the fine particles take a long time to settle.

Where practicable, accumulated dust should be removed using wet cleaning methods, or H-class filter vacuum methods. As workers undertaking cleaning work may be exposed to dust levels that exceed the exposure standard, they should wear RPE.

Servicing and maintenance

All machinery, plant and other production equipment must be regularly maintained, in accordance with the manufacturer's instructions, where its condition may affect the severity of the respirable dust hazard. For example, spray water equipment used to wet down the ash during conditioning should be maintained to ensure they are effective and operational.

Workers involved with major overhaul work and the maintenance of process, plant and equipment are often exposed to a greater potential hazard from respirable dust than other power station workers performing routine work. This is especially true in the maintenance of exhaust and other ventilation systems (e.g. fabric filter houses / bags) or with entry to coal pulverisers. Appropriate dust exposure controls must be in place before maintenance commences (e.g. washing down of pulverisers prior to maintenance).

5.5 Respiratory protective equipment

WHS Regulation section 44(2-4): The PCBU who directs the carrying out of work must provide the personal protective equipment to workers at the workplace, unless the personal protective equipment has been provided by another person conducting a business or undertaking.

The person conducting the business or undertaking who directs the carrying out of work must ensure that personal protective equipment provided under subsection (2) is -

- a) selected to minimise risk to health and safety, including by ensuring that the equipment is:
 - i. suitable having regard to the nature of the work and any hazard associated with the work; and
 - ii. a suitable size and fit and reasonably comfortable for the worker who is to use or wear it; and
- b) maintained, repaired or replaced so that it continues to minimise risk to the worker who uses it, including by ensuring that the equipment is -
 - i. clean and hygienic; and
 - ii. in good working order; and
- c) used or worn by the worker, so far as is reasonably practicable.

The PCBU who directs the carrying out of work must provide the worker with information, training and instruction in the -

- a) proper use and wearing of personal protective equipment; and
- b) the storage and maintenance of personal protective equipment.

WHS Regulation section 46(2-4): The worker must, so far as the worker is reasonably able, use or wear the equipment in accordance with any information, training or reasonable instruction by the PCBU.

The worker must not intentionally misuse or damage the equipment.

The worker must inform the PCBU of any damage to, defect in or need to clean or decontaminate any of the equipment of which the worker becomes aware.

Respiratory protective equipment (RPE) should never be used as the primary means for exposure control in situation when other higher order controls are available and effective.

In all uses of RPE, a RPE program should be established in accordance with applicable sections of AS/NZS 1715:2009 Selection, use and maintenance of respiratory protective equipment, for particular filter respirators. RPE for mitigation of dust controls should meet the relevant requirements for AS/NZS 1716:2012 Respiratory protective devices.

Respiratory protective equipment is the least effective form of mitigating dust exposure according to the hierarchy of controls, as it does not remove the hazard and relies on correct fit and use by the worker, as well as adequate supervision. However, RPE will generally form part of an overall dust control strategy if worn correctly for the full duration of the task.

Selecting suitable RPE

The appropriate respiratory protection should be determined by a competent person having regard to:

- its suitability to the hazard associated with the respirable dust generation and reduces exposure to the level required to protect the worker's health
- suitability of the filtration system for its proposed use
- its suitability to the worker (e.g. face shape; the size, fit and weight of the RPE; pre-existing medical conditions of the worker such as asthma; facial hair can prevent some types of respirators sealing appropriately)
- its suitability to the work task (e.g. length of time the worker would need to wear the RPE; other PPE that may be worker such as safety glasses that may interfere with the fit of the respirator; vision and communication requirements)
- its suitability to the environment (e.g. temperature or humidity).

Types of respirators include:

- respirators that use filters to remove contaminants from the air the wearer breathes
- powered air purifying respirators (PAPRs) where contaminated air is forced by a powered fan through filters to provide purified air for the wearer
- supplied air respirators that provide a supply of clean air from a source such as a cylinder or air compressor.

The figures below provide examples of some respirators that can be used. The protection afforded by each device depends on the design and fit of the respirator to the person and upon the efficiency of the filters (for instance, P2 or P3).



Figure 3: Re-usable half-face respirator (left) and full-face respirator (cartridge) (right).



Figure 4: Powered air purifying respirators.




Workers should be consulted on the selection of RPE to ensure individual fit and medical factors have been considered.

Particulate filters only protect against solid (e.g. dust) and liquid particles including microorganisms. They do not protect against gases or vapours such as solvent vapour. Particulate filters are classified and marked as P1, P2 or P3, with P3 providing the highest level of protection. P3 protection can only be achieved if the P3 filter is used in a full-face respirator.

Respirator selection guide





The following tables show examples of minimum RPE required depending on the level of air contamination based on AS/NZS 1715:2009 Selection, use and maintenance of respiratory protective equipment.

Table 4: Negative pressure respirators

Air contamination level	Half-face disposable		Half-face reusable		Full-face	
	Particulates	Gas/vapour	Particulates	Gas/vapour	Particulates	Gas/vapour
up to 10 times WES						
	P1*		P1*		P1*	
	P2	Class AUS Class 1 Class 2 Class 3	P2 P3	Class AUS Class 1 Class 2 Class 3		Class AUS Class 1 Class 2
up to 50 times WES					P2	Class AUS (1) Class 1 (1)
up to 100 times WES					P3	Class 2 (2) Class 3
over 100 times WES						
Unknown level						
Oxygen level of less than 19.5%						

*Tasks in work areas 10 times workplace exposure standard (WES) require professional advice on the RPE program.

Table 5: Positive pressure respirators

Air contamination level	Powered air (PAPR)		Air-hose		Air-line		SCBA	
	Particulates	Gas/vapour	Particulates	Gas/vapour	Particulates	Gas/vapour	Particulates	Gas/vapour
up to 10 times WES								
	P1*	Class AUS Class 1 Class 2						
up to 50 times WES								
up to 100 times WES		Class 2 (2)						
over 100 times WES			Y	Y	Y	Y	Y	Y
Unknown level							Y	Y
Oxygen level of less than 19.5%							Y	Y

Respirator selection example one

Workers carry out a process at the power station that causes airborne dust containing respirable crystalline silica, for eight to ten hours each day. The eight-hour TWA exposure standard for respirable crystalline silica is 0.05 mg/m³. Air monitoring results show the level of respirable crystalline silica in the workplace at 0.75 mg/m³. Table 6 below shows some RPE that may be suitable to protect a worker who is exposed up to 15 times the exposure standard for respirable crystalline silica.

Table 6: RPE suitable for worker exposed up to 15 times the exposure standard for respirable crystalline silica

Respirator type	Filter type	Comment
PAPR	P2	Suitable for wearing the whole shift and allows worker mobility
Full face reusable	P2	Not suitable for wearing the whole shift
Air-line using compressed air	Not applicable	Worker mobility may be restricted

Respirator selection example two

Workers carry a process at the power station that causes airborne dust containing respirable crystalline silica, for two hours each day. The eight-hour TWA exposure standard for respirable crystalline silica is 0.05 mg/m³. Air monitoring results show the level of respirable crystalline silica in the workplace at 0.15–0.25 mg/m³. Table 7 below shows some RPE that may be suitable to protect a worker who is exposed up to five times the exposure standard for respirable crystalline silica.

Table 7: RPE suitable for worker exposed up to 5 times the exposure standard for respirable crystalline silica

Respirator type	Filter type	Comment
PAPR	P1	Suitable for wearing the whole shift and allows worker mobility
Half face reusable or disposable	P1	Not suitable for wearing the whole shift
Air-line using compressed air	Not applicable	Worker mobility may be restricted

Fit testing

The performance of RPE depends on a good contact between the wearer’s skin and the face seal of the mask so that the mask is a tight-fitting face piece or full mask. A good face seal can only be achieved if the wearer is clean-shaven in the region of the seal and the face piece is the correct size and shape to fit the wearer’s face.

Facial hair, including beards, moustaches, sideburns and stubble, will stop a respirator from sealing properly. Workers who are required to wear tightfitting respirators, must be clean-shaven to allow a good seal of the respirator to the face.

Fit testing ensures that workers are wearing proper fitting RPE. As facial characteristics vary from person to person, it’s unlikely that one model or size of RPE will fit everyone. The RPE must be appropriate for the size of the face. In addition, some types of RPE (such as negative pressure respirators – those where a user draws air through a filter cartridge) must give a tight seal around the face to be effective.

Fit testing can also be a useful training exercise to teach workers how to wear their RPE correctly.

Fit testing should be carried out by a competent person:

- each time a new make or model of respirator is issued
- whenever there is a change in the wearer's facial characteristics or features which may affect the facial seal (e.g. large weight loss or gain).

Fit testing should be repeated on a regular basis based upon risk assessment, and one to two yearly is considered reasonable.

Maintenance of RPE

The WHS Regulation requires that RPE is maintained, repaired or replaced so as to ensure that it continues to be effective. Respiratory protective equipment maintenance should be carried out by a competent person in accordance with the manufacturer's instructions.

A maintenance program should include procedures for:

- daily cleaning and inspection of RPE by the worker for wear and damage
- appropriate storage, for example, in a dry, clean and sealed container
- identification and repair or replacement of any worn or defective components of the equipment (including availability of replacement parts)
- regular periodic inspection, maintenance and testing of respiratory protective equipment in accordance with the manufacturer's instructions
- record keeping.

6. Reviewing control measures

WHS Regulation section 37: A duty holder who implements a control measure to eliminate or minimise risk to health and safety must ensure that the control measure is, and is maintained so that it remains, effective, including by ensuring that the control measure is and remains -

- a) fit for purpose; and
- b) suitable for the nature and duration of the work; and
- c) installed, set up and used correctly.

WHS Regulation section 38 (2): The duty holder must review and, as necessary, revise a control measure in the following circumstances -

- a) the control measure does not control the risk it was implemented to control so far as is reasonably practicable;

Examples -

- the results of monitoring show that the control measure does not control the risk
 - a notifiable incident occurs because of the risk
- b) before a change at the workplace that is likely to give rise to a new or different risk to health and safety that the measure may not effectively control;
 - c) a new relevant hazard or risk is identified;
 - d) the results of consultation by the duty holder under the Act or this regulation indicate that a review is necessary;
 - e) a health and safety representative requests the review under subsection (4).

WHS Regulation section 352: A PCBU at a workplace must ensure that any measures implemented to control risks in relation to a hazardous chemical at a workplace are reviewed and, as necessary, revised in any of the following circumstances -

- a) following any change to the safety data sheet for the hazardous chemical or the register of hazardous chemicals;
- b) if the person obtains a health monitoring report for a worker under division 6 that contains -
 - i. test results that indicate that the worker has been exposed to the hazardous chemical and has an elevated level of metabolites in his or her body for that hazardous chemical; or
 - ii. any advice that test results indicate that the worker may have contracted a disease, injury or illness as a result of carrying out the work using, handling, generating or storing the hazardous chemical that triggered the requirement for health monitoring; or
 - iii. any recommendation that the PCBU take remedial measures, including whether the worker can continue to carry out the work using, handling, generating or storing the hazardous chemical that triggered the requirement for health monitoring.

- c) if monitoring carried out under section 50 determines that the airborne concentration of the hazardous chemical at the workplace exceeds the relevant exposure standard;
- d) at least once every 5 years.

The control measures that are put in place to protect health and safety should be regularly reviewed to make sure they are effective. This may involve, for example, air monitoring to measure the concentration of respirable dust in the worker's breathing zone during routine cleaning of power plant equipment. If the control measure is not working effectively, it must be revised to ensure it is effective in controlling the risk.

As outlined in section 4 Assessing the risks from respirable dust exposure, if the 95 per cent UCL of any SEG exceeds 50 per cent of the exposure standard, this is a trigger to undertake a review of exposure controls and their effectiveness.

Common review methods include workplace inspection, consultation with workers, testing and analysing records (e.g. air monitoring results) and incident data.

The same methods as in the initial hazard identification step can be used to check control measures. Consult workers and their health and safety representatives and consider the following questions:

- Are there any key triggers that indicate when controls are not working to their designed specification or operation?
- Have the control measures or revised control measures introduced new problems?
- Have all respirable dust hazards been identified?
- Have new work methods or new equipment made the job safer?
- Are safety procedures being followed?
- Has the training and instruction provided to workers on how to work safely been successful?
- Are workers actively involved in identifying respirable dust hazards and possible control measures?

If problems are found, go back through the risk management steps, review information and make further decisions about risk control.

Investigating exposure exceedances

If a personal single air monitoring sample result exceeds the relevant exposure standard, an investigation should be initiated. The aim of the investigation should be to determine the absent or failed control/s that contributed to the measured exposure, and to define the actions required (short and/or long term) to prevent a reoccurrence and the timeframe for their completion.

At a minimum, the investigation should consider the following:

- date of sample
- similar exposure groups and location
- crew affected
- activities/tasks carried out (including times)
- personal protective equipment and/or respiratory protective equipment used and for what activities/tasks (including times)
- controls in place
- production information
- materials in use
- operational conditions (e.g. normal/maintenance, shift/down time)

- environmental conditions
- operator location
- adjacent activities
- maintenance schedule vs actual – maintenance records for all equipment
- equipment pre-shift checks
- sampling data (determine is sample valid)
 - sampler
 - sample time
 - flow rate (pre, post, average)
 - calibration records of equipment
 - filter procedure followed.

Resampling following an investigation

The requirements to resample a SEG following an exceedance should be determined as the outcome of an investigation. Resampling should generally occur following the implementation of additional controls to verify their effectiveness at reducing exposure levels.

However, if sampling for the SEG is occurring frequently (e.g. monthly) as part of the respirable dust sampling plan, resampling may not be necessary. For some SEGs the investigation may trigger a review of the respirable dust sampling plan requirements, resulting in an increase in the number of samples and/or the frequency of monitoring required.

7. Health monitoring

WHS Regulation section 368: A PCBU must ensure that health monitoring is provided to a worker carrying out work for the business or undertaking if -

- a) the worker is carrying out ongoing work at a workplace using, handling, generating or storing hazardous chemicals, and there is a significant risk to the worker's health because of exposure to a hazardous chemical referred to in Schedule 14, table 14.1
- b) the person identifies that because of ongoing work carried out by a worker using, handling generating or storing hazardous chemicals there is a significant risk that the worker will be exposed to a hazardous chemical (other than a hazardous chemical referred to in Schedule 14, table 14.1) and either:
 - i. valid techniques are available to detect the effect on the worker's health; or
 - ii. a valid way of determining biological exposure to the hazardous chemical is available and it is uncertain, on reasonable grounds, whether the exposure to the hazardous chemical has resulted in the biological exposure standard being exceeded.

Health monitoring of a person means monitoring the person to identify changes in the person's health status because of exposure to certain substances. Health monitoring aims to detect adverse health effects at an early stage so action may be taken.

Under the WHS Regulation, a PCBU must ensure that health monitoring is provided to a worker where they carry out ongoing work using, handling, generating or storing hazardous chemicals or substances (e.g. coal dust, respirable crystalline silica) and there is a 'significant risk' to the worker's health because of exposure to the hazardous chemical or substance.

Health monitoring is not an alternative to implementing control measures. If the results indicate that a worker is experiencing adverse health effects or signs of illness to a hazardous chemical, the control measure must be reviewed and if necessary revised.

Determining what is a 'significant risk'

The risk of exposure may generally be described as 'not significant' or 'significant'.

The level of risk to workers from exposure to a substance depends on the type of dust as well as the frequency, duration and amount of exposure (i.e. the dose). The degree of exposure of workers in the workplace needs to be determined taking into account:

- work practices and procedures and the way workers carry out their daily tasks
- whether existing control measures adequately control exposure
- results of air monitoring for airborne contaminant levels (these will provide information about the degree of exposure in the workplace, as well as whether control measures are working effectively).

The risk can be regarded as 'not significant' if it is unlikely the worker will be exposed at a level that would adversely affect his or her health. A 'significant risk' means people in the workplace are likely to be exposed at a level that could adversely affect their health.

For the purposes of this code, where the 95 per cent UCL of any SEG exceeds 50 per cent of the exposure standard this is considered to be 'significant risk' and is a trigger to undertake health monitoring.

Providing a health monitoring program

A PCBU must:

- inform workers and prospective workers about health monitoring requirements
- ensure health monitoring is carried out by or under the supervision of a registered medical practitioner with experience in health monitoring
- consult workers in relation to the selection of the registered medical practitioner
- pay all expenses relating to health monitoring
- provide certain information about a worker to the registered medical practitioner
- take all reasonable steps to obtain a report from the registered medical practitioner as soon as practicable after the monitoring has been carried out
- provide a copy of the report to the worker and the regulator if the report contains adverse test result or recommendations that remedial measures should be taken. Also provide the report to all other PCBUs who have a duty to provide health monitoring for the worker
- keep reports as confidential records for at least 30 years after the record is made (40 years for reports relating to asbestos exposure)
- not disclose the report to anyone without the worker's written consent unless required under the WHS Regulation.

Valid techniques available to detect the effect on the worker's health

There are a number of valid techniques available for health monitoring for respirable coal dust exposure at coal-fired power stations and these are detailed in the Coal Mine Workers' Health Scheme Clinical Pathways Guidelines (www.dnrme.qld.gov.au). Any health monitoring undertaken should be carried out in a manner consistent with these guidelines under the supervision of a registered medical practitioner with experience in health monitoring. This ensures that the same diagnostic process is followed for all workers exposed to coal dust in Queensland.

These guidelines provide for:

1. A chest X-ray to be reviewed by two qualified b-readers with additional readers available for adjudication. A b-reader is a radiologist who has undertaken specialised training to detect coal dust lung diseases such as coal workers' pneumoconiosis, silicosis, mixed dust pneumoconiosis and progressive massive fibrosis
2. Spirometry (lung function) testing which is used to detect conditions such as emphysema, bronchitis, dust induced fibrosis and acute silicosis.

Under the guidelines, if the results of these tests are positive then a referral should be made to a respiratory physician for further investigations and diagnosis.

In order to reduce radiation exposure, the frequency of chest X-rays should be minimised. There is potential for excessive X-rays with a workforce that changes employers frequently. The frequency of chest X-rays during the health monitoring program should be determined by a registered medical practitioner with experience in health monitoring.

In relation to health monitoring for respirable crystalline silica, it is referred to in Schedule 14 of the WHS Regulation. Schedule 14 lists the requirements which the medical practitioner will conduct in the health monitoring. This may include chest X-ray, spirometry (lung function) testing, questionnaire and taking an exposure history.

Further information on health monitoring can be found in the health monitoring guides available at www.safeworkaustralia.gov.au.

8. Information, training, instruction and supervision

WHS Act section 19(3)(f): A PCBU must ensure, so far as is reasonably practicable, the provision of any information, training, instruction or supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out as part of the conduct of the business or undertaking.

WHS Regulation section 39 (2-3): A PCBU must ensure that information, training and instruction provided to a worker is suitable and adequate having regard to -

- a) the nature of the work carried out by the worker; and
- b) the nature of the risks associated with the work at the time of the information, training and instruction; and
- c) the control measures implemented.

The person must ensure, so far as is reasonably practicable, that the information, training and instruction is provided in a way that is readily understandable by any person to whom it is provided.

Workers must receive information and training on the risks from respirable dust along with all other risks at the workplace.

The aim of this training is to education workers on the hazards, risks, potential health impacts and effective control mechanisms for known respirable hazards and risks in coal-fired power plants.

This training should include:

- what is respirable dust – including silica dust and coal dust
- health information relating to excessive exposure to different types of dust and in particular dust containing respirable crystalline silica at levels greater than one percent
- the effects of respirable dust on a worker
- known dust exposure and outcomes (e.g. pneumoconiosis – including coal workers' pneumoconiosis and silicosis, resulting from breathing coal dust and/or silica)
- high risk exposure areas on site and probable exposure levels associated with the type of job being undertaken
- the role and significance of dust sampling and monitoring for respirable dust and relevant workplace exposure standards
- how to mitigate and manage the impacts of the respirable dust on workers
- correct usage of controls, including RPE and other personal protective equipment
- the importance of controlling the creation of dust in the atmosphere and how the hierarchy of controls for dust management is applied
- health monitoring.

In addition, workers involved in activities should be provided with more general work health and safety information and training including:

- the effects of noise on their hearing and health
- Queensland's work health and safety laws, including relevant parts of this code of practice
- the work health and safety policies, and relevant procedures at the workplace
- the risk management process

- inspection and maintenance programs in place at the workplace
- how to access information such as manufacturer's instructions about hazards
- emergency procedures, including staff with specific emergency roles and responsibilities.

Information, training and instruction must be provided in such a way that it is easily understood. Records of training provided to workers should be kept, documenting who was trained, when and on what.

Appendix 1: Similar exposure group (SEG) descriptive statistics

The table below shows descriptive statistics with a brief explanation of their use.

Statistical measure	Description								
Number of samples	This will usually be the SEG sample target. At least six samples are required to perform statistical analysis of a dataset.								
Minimum/maximum	Describes the range of exposure values in a given dataset for a SEG.								
Estimated arithmetic mean	Estimated average exposure of the SEG.								
Geometric standard deviation (GSD)	A measure of the spread of data in a dataset. It's expected that most exposures in a SEG are generally the same. If there is a significant variation in a dataset, this will be reflected by the value of the GSD. High GSD value may indicate a need to undertaking additional sampling or to review the accuracy of the SEGs definition.								
	<table border="1"> <thead> <tr> <th>GSD value</th> <th>Degree of data spread</th> </tr> </thead> <tbody> <tr> <td>1.0 - 2.0</td> <td>Data clustered around the mean – minimal variation</td> </tr> <tr> <td>2.0 - 3.0</td> <td>Moderate variation in the dataset, potentially due to: <ul style="list-style-type: none"> elevated individual samples samples below the limit of reporting insufficient number of samples. </td> </tr> <tr> <td>> 3.0</td> <td>Significant variation in the dataset, potentially due to: <ul style="list-style-type: none"> significant outliers in the dataset incorrectly defined SEG insufficient number of samples. </td> </tr> </tbody> </table>	GSD value	Degree of data spread	1.0 - 2.0	Data clustered around the mean – minimal variation	2.0 - 3.0	Moderate variation in the dataset, potentially due to: <ul style="list-style-type: none"> elevated individual samples samples below the limit of reporting insufficient number of samples. 	> 3.0	Significant variation in the dataset, potentially due to: <ul style="list-style-type: none"> significant outliers in the dataset incorrectly defined SEG insufficient number of samples.
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95% upper confident limit	This represents the value below which, a person can be 95% confident lies the true value of the SEG's mean exposure.								

Appendix 2: Minimum data collection requirements for personal sampling records

Minimum data collection requirements for personal sampling records

Worker	
Details of sampled worker (name/employee number)	Task/activity performed
Employment status (employee/contractor)	Shift rotation and length
Job title/description	Comments
SEG	
Sample	
Sample date	Flow rates (initial/final/average)
Sampler (competent person)	Sampling duration (sample start/finish times)
Lab ID/filter ID/size selective sampler ID	Void reason (if applicable)
Sampling equipment, including calibrators (serial no calibration status)	
Work environment	
Worker's normal tasks	Operational conditions (normal/maintenance/shutdown/spills)
Controls (including effectiveness)	Weather
Exposure sources (including adjacent activities)	Ventilation
Housekeeping status	Other relevant information
Operator interaction with exposure sources	

Example of a worker diary to be completed during personal sampling

Worker				
Name:		Employee status: Employee/contractor		
Employee number:		Crew: A/B/C/D		
Job title:		Shift rotation and length:		
Sample date:		SEG:		
Sampler				
Filter number:		Calibration date:		
Pump number:		Calibration date:		
Activity log				
Time	Activity performed/ID of equipment/vehicle operated	Location	RPE used?	Type of RPE used
0600 - 0700			Y/N	
0700 - 0800			Y/N	
0800 - 0900			Y/N	
...			Y/N	
Work environment				
Describe conditions: Are controls (e.g. spray) working? (Y/N) If not, why?				
Other comments				

Appendix 3: Single sample exceedance result (SSER) reporting form

A single sample exceedance result (SSER) is a single air monitoring sample result that exceeds the relevant eight-hour equivalent exposure standard. A SSER is a trigger to investigate and review control measures.

This form should be used to record a summary of the sampling result, in a format that meets the requirements under the code of practice.

In the event of a SSER, the person conducting the business or undertaking (PCBU) should:

- submit the completed form to OHHA@oir.qld.gov.au
- inform the WHS Regulator at OHHA@oir.qld.gov.au on the further action taken, as soon as reasonably practicable following the investigation and review of control measures

Note: A SSER reporting form—coal-fired power stations should be submitted for each separate SSER.

This form can also be used by the PCBU to meet the additional reporting requirements within the workplace.

Section 1 – Reporting PCBU details	
Business name	
ABN	
Site address	
Contact name	
Contact phone	
Contact email	
Section 2 – Worker details	
Provide the following information for details of results where a SSER occurred (including details of existing controls in use and if RPE was in use, the type of RPE).	
Worker name	
Workers' contact details	
Similar exposure group (SEG)	
Site	

Workgroup	
Supervisor	
Supervisor's contact details	
Has the worker experienced a single sample exceedance result previously	Y/N
If yes, provide details	
Section 3 – Sample details	
Provide the following information on the nature of the sample results.	
Sample number	
Sample date	
Sample duration (minutes)	
Location where the sample was taken	
Airborne contaminant sampled	Options – Respirable crystalline silica, respirable coal dust.
Sample result (mg/m³)	
Relevant exposure standard (mg/m³) (shift adjusted where required)	
Shift adjustment method	Options – N/A, Brief and Scala Model, OSHA Model, Pharmacokinetic Model, Quebec Model, other (describe).

Occupational hygienist who conducted respirable dust monitoring	Name/company/contact details
Section 4 – Description of existing controls and workplace conditions at time of sampling	
Provide the following information for details of results where a SSER occurred (including details of existing controls in use and if RPE was in use, the type of RPE).	
Details of activities conducted by the worker (brief description):	
Description of controls used to eliminate or minimise exposure to respirable dust	
Make, model and filter type of respiratory protective equipment (RPE) used by worker	
If tight-fitting RPE used, was worker fit tested and clean shaven on day of sampling?	Fit-tested: Y / N
	Clean shaven: Y / N
Worker's description of the housekeeping conditions where the work activity was performed	

<p>General description of environmental conditions where the work activity was performed</p>	
<p>Section 5 – Summary of investigation findings</p>	
<p>Summarise the initial findings of the investigation into the SSER, taking into account any issues identified in Sections 3 and 4.</p>	
<p>Section 6 – Proposed corrective and preventative actions</p>	
<p>Provide the following information on any interim corrective actions, including:</p> <ul style="list-style-type: none"> • what is being considered • the process for consideration • how actions will be determined. 	
<p>(Include any interim controls which have been implemented)</p>	