Resources Safety & Health
Queensland

QGL02 - Guideline for management of respirable dust in Queensland mineral mines and quarries

Mining and Quarrying Safety and Health Act 1999

April 2021
Version: 4.0

This guideline received input from and review by the Resources Safety & Health Queensland (RSHQ) Mines Inspectorate occupational hygienists, and the Mining Safety and Health Advisory Committee (MSHAC). Organisations represented on the MSHAC include: the Australian Workers' Union; Australian Manufacturers' Workers Union; Cement Concrete & Aggregates Australia (Queensland), Queensland Resources Council; and RSHQ.

This publication has been compiled by RSHQ

Interpreter statement:

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This document is issued in accordance with PART 5—Guidelines and Section 63(1) of the Mining and Quarrying Safety and Health Act 1999. Below are relevant excerpts from the Act.

PART 5—Guidelines

62 Purpose of guidelines

A guideline may be made for safety and health stating ways to achieve an acceptable level of risk to persons arising out of operations.

63 Guidelines

(1) The Minister may make guidelines.

(2) The Minister must notify the making of a guideline by gazette notice.

(3) The CEO must publish on a Queensland government website each guideline and any document applied, adopted or incorporated by the guideline.

(4) In this section—

Queensland government website *means a website with a URL that contains 'qld.gov.au', other than the website of a local government.*

64 Use of guidelines in proceedings

A guideline is admissible in evidence in a proceeding if—

(a) the proceeding relates to a contravention of a safety and health obligation imposed on a person under part 3; and

(b) it is claimed that the person contravened the obligation by failing to achieve an acceptable level of risk; and

(c) the guideline is about achieving an acceptable level of risk.

Division 1: Control and management of risk

26 What is an acceptable level of risk

(1) For risk to a person from operations to be at an acceptable level, the operations must be carried out so that the level of risk from the operations is—

(a) within acceptable limits; and

(b) as low as reasonably achievable.

(2) To decide whether risk is within acceptable limits and as low as reasonably achievable regard must be had to—

(a) the likelihood of injury or illness to a person arising out of the risk; and

(b) the severity of the injury or illness.

Part 3—Safety and health obligations

34 How obligation can be discharged if regulation or guideline made—

(1) If a regulation prescribes a way of achieving an acceptable level of risk, a person may discharge the person's safety and health obligation in relation to the risk only by following the prescribed way.

(2) If a regulation prohibits exposure to a risk, a person may discharge the person's safety and health obligation in relation to the risk only by ensuring that the prohibition is not contravened.

(3) Subject to subsections (1) and (2), if a guideline states a way or ways of achieving an acceptable level of risk, a person discharges the person's safety and health obligation in relation to the risk only by—

(a) adopting and following a stated way; or

(b) adopting and following another way that achieves a level of risk that is equal to or better than the acceptable level.

Note—
For this section and the following section, see defences provided for under division 4.

The words 'shall', 'must' or 'mandatory' place a legal obligation on the identified person or entity. The word 'should' indicates a recommended course of action, while 'may' indicates an optional course of action.

This guideline is issued under the authority of the Minister for Resources and applies to all Queensland mineral mines and quarries.

[Gazetted 14 May 2021]

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1 Purpose and scope

This Guideline provides a way for a site senior executive (SSE) and other persons to:

- Identify, analyse and monitor risk associated with respirable dust hazards;
- Establish and maintain effective controls associated with respirable dust hazards.

The term ‘respirable dust’ used in in this Guideline includes respirable crystalline silica and other airborne, respirable particulates.

This Guideline applies to all Queensland mineral mines and quarries.

This Guideline, version 4, supersedes version 3 and commences from the date of gazettal.

2 Introduction

An SSE must ensure a worker's exposure to respirable dust and other air contaminants, such as respirable crystalline silica (RCS) does not exceed the exposure limit and is as low as reasonably achievable[1].

Previous versions of this Guideline have focused solely on respirable crystalline silica. While RCS is an important health hazard, mine dust lung disease (MDLD) can also be caused by exposure to other respirable dusts. Therefore, the scope of this Guideline has been broadened to include respirable dust, in general.

Respirable dust includes very small particles of dust (diameter less than 10 microns) that when inhaled are able to reach the deepest parts of the lungs. Workers exposed to elevated levels of airborne respirable dust have an increased risk of developing MDLD such as pneumoconiosis, chronic obstructive pulmonary disease (COPD) and lung cancer. Often a worker with MDLD has more than one of these diseases (e.g. pneumoconiosis and COPD). MDLD is also typically a slowly progressive disease that may not become apparent for many years after exposure has occurred.

The type of disease that occurs is also influenced by mineral composition. For example, respirable dust may contain respirable crystalline silica. Crystalline silica, due to its chemistry, is particularly harmful when its crystalline structure is freshly broken/fractured (e.g. by mechanical means such as drilling, excavation or crushing), it is of respirable size and deposited into the lower parts of the lungs. Exposure to respirable crystalline silica at levels above the exposure limit can result in silicosis and, in some cases, lung cancer.

Furthermore, this version of the Guideline has added emphasis on establishing effective and reliable respirable dust control measures.

[1] MQSHR section 135 Limiting workers' exposure

3 Risk management process

Assessing risk associated with respirable dust can be a complex process due to the requirement to undertake specific risk management techniques. Figure 1 outlines the risk management process described in this Guideline.

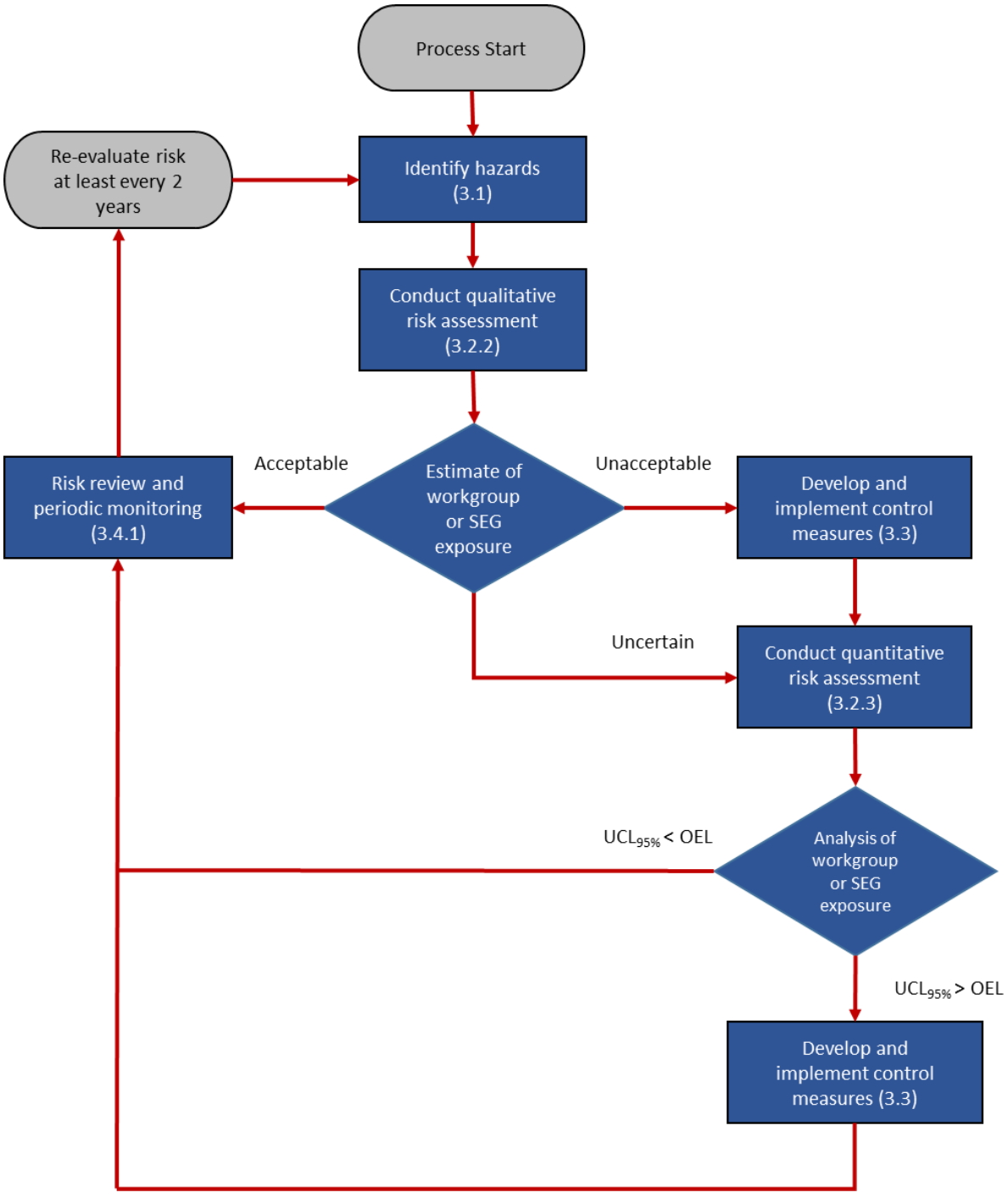

Figure 1 - Risk management process

As with other risks, the SSE must document and maintain a management structure for the mine in a way that

allows development and implementation of the safety and health management system (SHMS)[2].The management structure must state the names, responsibilities and competencies held by senior persons in the structure with an obligation to manage respirable dust risks at the mine[3].

3.1 Identifying hazards

The operator and SSE have obligations to identify respirable dust hazards

The operator must ensure that respirable dust hazards are identified during the operation's planning and design stage[4].

Anticipating respirable dust hazards during planning and design provides an opportunity for the operator to reduce risk to an acceptable level through the early application of the hierarchy of controls to:

- the mine plan, processing, and infrastructure design, including mine ventilation;
- the procurement and selection of plant, equipment, materials and products;
- working arrangements such as shift and roster design;
- other environmental factors such as prevailing weather conditions and proximity to local communities and sensitive receptors.

Hazard anticipation, by the operator, is also particularly important in circumstances where it is planned to extend the mine's life beyond that which was originally planned and designed.

Furthermore, the SSE must ensure that respirable dust hazards are identified:

- when operations start;
- during operations;
- when operations change in size, nature, complexity or another way[5].

A person who has an obligation to identify respirable dust hazards should consider:

- operations that may cause respirable dust to be released into the air, such as:
    - land clearing in preparation for mining;
    - exploration or production drilling;
    - loading blast holes or blasting;
    - ripping, digging or excavating;
    - mucking, loading or tipping;
    - road making or maintenance;
    - transporting or conveying;
    - crushing or screening;
    - cutting or grinding or abrasive blasting;
    - drying or calcining;

[2] MQSHA section 50 Management structure for safe operations at mines
[3] MQSHR section 6(1) Hazard identification, section 7(1) Risk analysis, section 8(1) Risk reduction, and section 9(1) Risk monitoring apply to persons who have an obligation under the Act to manage risk at a mine
[4] MQSHR section 6(2) Hazard identification
[5] MQSHR section 6(3) Hazard identification

    - bagging, palletising or load-out;
    - maintenance;
    - housekeeping or cleaning (e.g. dry sweeping, use of compressed air for cleaning and 'blowing-out').
- whether rock or waste material contains specific respirable dust hazards such as crystalline silica.
- For example, the crystalline silica content of:
    - sandstone: >70%;
    - shale: 40 – 60%;
    - granite: Up to 30%;
    - clays and bentonite: 6 – 30%;
    - basalt/dolerite: Up to 5%;
    - limestone/marble: Up to 2%.
- whether other materials and products used during operations contain specific respirable dust hazards such as crystalline silica. For example, the crystalline silica content of:
    - concrete/mortar: 25 – 75%;
    - tile: 30 – 45%;
    - brick: up to 30%.
- duration of a worker's exposure to respirable dust during operations.

3.2 Analysing risk

Workers' exposure to respirable dust must be analysed to decide if risk is at an acceptable level

The SSE must ensure that the identified respirable dust hazards are analysed to decide whether risk to workers is at an acceptable level.

A person who has an obligation to analyse risk associated with respirable dust hazards should consider:

- the results of hazard identification, risk monitoring and exceedance investigations carried out for the operation;
- the work environment and work methods for operations;
- the interaction of hazards present in the operation;
- the effectiveness and reliability of control measures in use at the operation;
- other reasonably available relevant information and data from; and practices in, other industries and mining operations[6].

3.2.1 Exposure limits for respirable dust and crystalline silica

Exposure limits must be referenced from the regulation

The occupational exposure limit (OEL) for respirable dust, RCS and other airborne contaminants must be referenced from the most recent version of the *Mining and Quarrying Safety and Health Regulation*, *Schedule 5 – General exposure limits for hazards.*

[6] MQSHR section 7(2) Risk analysis

3.2.2 Qualitative risk assessment of workers' exposure

Respirable dust levels must firstly be estimated to determine the level of risk

The SSE must ensure that an estimate of workgroup or SEG exposure to respirable dust is undertaken using a qualitative risk assessment, in consultation with an occupational hygienist[7].

After reviewing the information obtained in sections 3.1, 3.2 and 3.2.1 of this Guideline, the following risk criteria must be used:

- **Acceptable** – Estimate of exposure is less than 10% of the exposure limit applying to workers[8].
- **Uncertain** – Estimate of exposure is between than 10% and 100% of the exposure limit applying to workers[9].
- **Unacceptable** – Estimate of exposure is greater than 100% of the exposure limit applying to workers.

The qualitative risk assessment must be documented and comply with section 3.5.1 of this Guideline.

3.2.3 Quantitative risk assessment of workers' exposure

Respirable dust levels must be measured if respirable dust levels have the potential to exceed the exposure limit

The SSE must ensure that a quantitative risk assessment[10] is conducted if the qualitative risk assessment estimates that workgroup or SEG exposure to respirable dust is:

- uncertain; or
- unacceptable.

The SSE, in consultation with an occupational hygienist, must develop and document an exposure assessment plan that details sampling requirements for each workgroup or SEG using the appropriate methods and strategies stated in **Appendix 3**.

When the number of valid samples stated in the exposure assessment plan have been collected, an occupational hygienist must conduct the statistical analysis stated in **Appendix 5** to analyse risk of exposure.

The risk of workgroup or SEG exposure to respirable dust shall be considered acceptable if the Land's Upper Confidence Limit (UCL95%) is less than the appropriate OEL.

At the completion of the quantitative exposure assessment, an occupational hygienist must provide a written report to the SSE that includes:

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7 Qualitative risk assessment is a 'best estimate' of workgroup or SEG exposure based on the professional judgement of the occupational hygienist. When valid statistical data becomes available for workgroup or SEG exposure, it should be considered using the statistical measure of 'Acceptable' exposure stated in section 3.2.3

8 For RCS, where workgroup or SEG exposure is estimated to be below 0.02 mg/m³ , exposure may be considered 'Acceptable' (i.e. A review of RCS health effects conducted for Safe Work Australia in 2019 recommended that 0.02 mg/m³ is protective for silicosis and lung fibrosis, and minimises the risk of lung cancer)

9 For RCS, where workgroup or SEG exposure is estimated to be between 0.02 mg/m³ and 100% of the exposure limit applying to workers, exposure may be considered 'Uncertain'

10 Sometimes referred to as a baseline exposure assessment

- risk of exposure for each workgroup and SEG;
- an explanation of the quantitative risk assessment statistical analysis to the SSE;
- recommendations for the reduction of exposure;
- any periodic monitoring requirements (see section 3.4.1 of this Guideline).

The quantitative risk assessment must be documented and comply with section 3.5.1 of this Guideline.

If while carrying out the exposure assessment plan, a single sample exceeds the applicable OEL, the SSE must ensure that an investigation is conducted as per the requirements stated in section 3.4.2 of this Guideline.

Further guidance on conducting a quantitative risk assessment of workers' exposure can be found in the following references:

- Occupational hygiene monitoring and compliance strategies (Grantham & Firth, 2014).
- A strategy for assessing and managing occupational exposures (Ignacio & Bullock, 2006).

3.3 Reducing risk

When the qualitative or quantitative risk assessment determines that the risk of exposure to respirable dust is not at an acceptable level, the SSE must ensure that hazard controls are used to reduce risk.

3.3.1 Hierarchy of control

The hierarchy of control must be applied when controlling respirable dust

The hierarchy of control ranks the reliability and effectiveness of controls (See Figure 2). Controls at the top the hierarchy are more effective and reliable than controls at the bottom of the hierarchy.

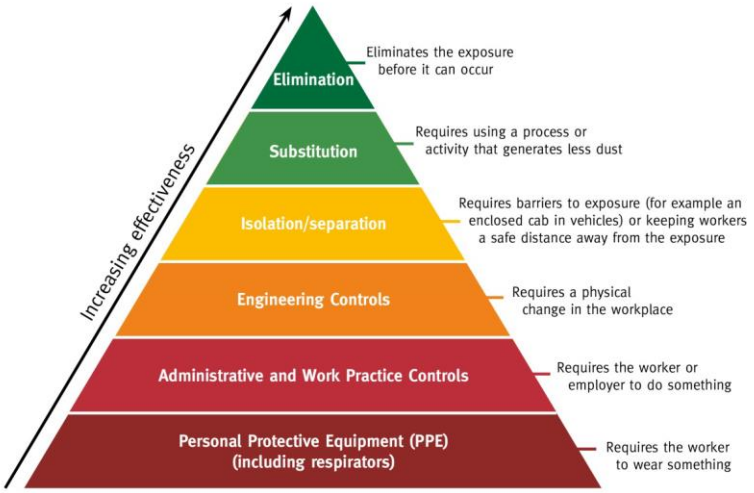

Figure 2 - Hierarchy of control

The measures used to control respirable dust must be reasonably practicable

A person who has an obligation to manage risk associated with respirable dust must, as far as reasonably

practicable, apply hazard controls starting at the top of the hierarchy[11].

When applying controls, 'reasonably practicable' means taking into account and weighing up all relevant matters including:

- the likelihood of the hazard or the risk concerned occurring; and
- the degree of harm that might result from the hazard or the risk; and
- what the person knows, or reasonably ought to know, about the hazard or risk, and about the ways of eliminating or minimising the risk; and
- the availability and suitability of ways to eliminate or minimise the risk; and
- after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk[12].

In many cases, a number of control measures may need to be implemented to ensure workers' exposure to respirable dust does not exceed the exposure limit and is as low as reasonably achievable.

Further guidance about how to determine what is reasonably practicable is provided in the following reference:

- How to determine what is reasonably practicable to meet a health and safety duty (Safe Work Australia, 2013).

3.3.2 Establishing and maintaining effective and reliable controls

Hazard controls used to reduce exposure to respirable dust must be effective and reliable

The SSE must ensure that hazard controls used to reduce the risk of workers' exposure to respirable dust in the work and local environments are appropriate having regard to the following:

- the interaction of hazards present in the work and local environments;
- the effectiveness and reliability of the controls, this includes measuring control effectiveness post implementation (i.e. real-time sampling, static sampling, inspection, observation); and
- other reasonably available relevant information; and data from, and practices in, other industries and mining operations[13].

Where controls that include plant, equipment or systems are established to prevent respirable dust entering a worker's breathing zone, the SSE must ensure the following information is documented:

- description of hazard and control/s;
- person/role responsible for the control/s;
- objective/goal of the control/s;
- technical specifications and performance requirements of the control/s;
- activities that maintain the effectiveness and reliability of the control/s;

[11] MQSHR section 8(1) Risk reduction
[12] Safe Work Australia (2013)
[13] MQSHR section 8(2) Risk reduction

- activities that verify control performance (i.e. inspection or testing); and
- person/role responsible for control verification activities.

Further guidance for developing and implementing effective and reliable controls arising from work-related exposures is provided in the following references:

- NIOSH Dust Control Handbook for Industrial Minerals Mining and Processing 2nd Edition
- Safe Work Australia – Work with silica and silica containing products
- Breathe Freely Australia – Breathe Freely in Mining
- ICMM Health and Safety Critical Control Management Good Practice
- ICMM Critical Control Management Implementation Guide

3.3.3 Training and awareness

Workers need to be made aware of respirable dust hazards at the mine and the control measures to prevent exposure

The SSE must ensure that workers with the potential for exposure to respirable dust hazards are made aware of the specific risks and controls:

- as part of the induction and refresher training[14];
- whenever significant changes are made that impacts on the respirable dust risk.

The following information about respirable dust hazards must be provided to workers:

- the location of respirable dust hazards;
- activities that create respirable dust risk to workers, noting that a lack of visible dust is not a reliable indicator of respirable dust risk;
- how respirable dust, including RCS may affect workers such as pneumoconiosis, chronic obstructive pulmonary disease, lung cancer, noting that no symptoms may be present in the early stages of MDLD;
- control measures that have been implemented and how they are to be checked and maintained
- process to report substandard conditions or practices;
- selection, use, storage and maintenance of respiratory protection, (including respirator fit testing when required).

The SSE must ensure a record of training (and any assessment of training) is kept for each worker[15].

Further sources of information about respirable dust, MDLD, and the purpose of health surveillance are provided in the following references:

- Miners' Health Matters
- Pocket Guides - Mine Dust Lung Disease
- Breathe Freely Australia – Breathe Freely in Mining
- Cancer Council – Occupational Cancer Risk Series Silica Dust

[14] MQSHR section 91 Induction training and assessment & MQSHR section 93 Training
[15] MQSHR section 94 Record of training

- NIOSH Dust Control Handbook for Industrial Minerals Mining and Processing 2nd Edition

3.3.4 Selection, use and maintenance of respiratory protection

Respiratory protective equipment may be used if workers' exposure cannot be prevented or reduced by other controls

The SSE shall ensure that respiratory protective equipment (RPE) is used if a worker's exposure cannot be prevented or reduced by other controls.

The SSE must ensure that:

- workers are given suitable and effective RPE;
- workers are competent in using the RPE and given instructions as to when and where it must be used;
- work load and work cycle are reduced as required to allow for increased physical demands of the RPE;
- fit-testing to check the effectiveness of RPE facial seal is mandatory if the workgroup or SEG UCL95% > OEL;
- facial hair rules to ensure RPE facial seal are mandatory if the workgroup or SEG UCL95% > OEL;
- RPE compliance checks are regularly conducted by supervision;
- the selection, use and maintenance of RPE conforms to AS/NZS 1715 – Selection, use and maintenance of respiratory protection.

3.4 Monitoring risk

3.4.1 Risk review and periodic monitoring

Workers' exposure to respirable dust must be monitored and the results analysed regularly

The SSE must ensure that workers' exposure to respirable dust is monitored and that the results are analysed regularly[16].

The purpose of regular risk review and periodic monitoring is to assess changes to the size, nature and complexity of operations and to check control effectiveness.

Hazard identification and review of the qualitative risk assessment for each workgroup and SEG must be conducted at least every two years.

Where a quantitative risk assessment was previously conducted, an occupational hygienist, in consultation with the SSE, shall develop and document a periodic exposure monitoring plan that monitors the relevant workgroup or SEG using the methods and strategies stated in **Appendix 3** of this guideline.

Periodic monitoring must be documented and comply with section 3.5.2 of this Guideline.

If while carrying out the periodic exposure monitoring plan a single sample exceeds the applicable OEL, the

[16] MQSHR section 136(2) Monitoring workers' exposure.

SSE must ensure that an investigation is conducted as per the requirements stated in section 3.4.2 of this Guideline.

At least every two years and prior to the hazard identification step of the risk management process being commenced (See Figure 1), an occupational hygienist must conduct a statistical analysis using the periodic monitoring data collected for each workgroup or SEG.

3.4.2 Investigation of a single sample exceedance

An investigation must be completed if a sample exceeds the applicable exposure limit

The SSE shall ensure that an investigation is undertaken where a single sample exceeds the applicable OEL[17].

The investigation must identify the cause of the exceedance and the control measures or actions that will be taken to prevent or eliminate a further exceedance.

The SSE must ensure that the investigation report and corrective actions are communicated to workers and recorded in the mine record[18].

3.4.3 Communicating and reporting sampling results

An occupational hygienist must review the exposure monitoring results and provide a report to the SSE with recommendations for control measures.

The SSE shall ensure that an occupational hygienist reviews the results as soon as practicable after receipt.

The occupational hygienist shall compare the exposure monitoring results to the appropriate OEL or the shift-adjusted OEL for the worker.

Within 28 days of any exposure monitoring, the Occupational Hygienist shall provide the SSE with a written report about the exposure monitoring.

The report shall include:

- a statement that sampling was conducted in accordance with AS2985;
- name of worker(s) monitored;
- name of occupational hygienist or occupational hygiene technician conducting sampling;
- name, qualifications, and years of experience of occupational hygienist reviewing report;
- monitoring date(s);
- average pump flowrate;
- duration of monitoring;
- each worker's duties, roles or tasks at the time of monitoring;
- workgroup or SEG affiliation;
- comment for each sample as to whether it is representative of the worker exposure;
- exposure monitoring results compared to the applicable OEL;

[17] MQSHR section 15 Site senior executive's investigation of incidents.
[18] MQSHA section 59 Mine record

    - including whether any result is an exceedance,
    - whether the worker wore RPE, and the type if worn
- for each exceedance, a summary of observed or reported activity for the worker on the day of monitoring;
- any invalid samples;
- practicable recommendations for actions or control measures to reduce exposure to below the applicable OEL and as low as reasonably achievable.

The SSE must ensure that every worker who was sampled or monitored is provided with their personal exposure monitoring result as soon as practicable.

The SSE must ensure that the mines inspectorate is notified within 28 days of becoming aware of the results of dust sampling. The notification shall be in the form published by the chief inspector.

3.4.4 Health surveillance

Respiratory health surveillance is required unless the workers' current and previous exposure to respiratory hazards is shown to be so minimal that any risk can be managed without respiratory health surveillance.

The SSE must ensure that respiratory health surveillance has been arranged for all workers as per QGL04 Guideline for respiratory health surveillance of workers in Queensland mineral mines and quarries[19].

3.4.5 Review and audit

The effectiveness of the SHMS and any specific hazard management plan for the control of respirable dust and RCS must be periodically audited and reviewed

The operator shall audit and review the effectiveness of the SHMS[20], including respirable dust management to ensure risk to persons is at an acceptable level, including:

- ensuring monitoring is undertaken at appropriate intervals;
- sufficient samples are collected for statistical analysis;
- sampling and analysis is undertaken by competent persons;
- exceedances are identified and investigated; and that appropriate, effective, control measures are implemented.

Further guidance about review and audit of the safety and health management system developing is provided in the following reference:

- Guidance Note QGN09 – Reviewing the effectiveness of safety and health management systems.

[19] MQSHR section 145C requirement to arrange respiratory health surveillance
[20] MQSHA section 38(1)(e) Obligations of operators

3.5 Record keeping

3.5.1 Risk management records

Records of risk management activities must be kept until a hazard is no longer present at an operation

The SSE must ensure that a record of the risk management process is made containing the following details:

- names of the persons involved in the risk assessment and their respective positions in the mine's management structure;
- a description of the hazard;
- the method used for assessing the likelihood and consequences of the risk; and
- the controls proposed to reduce the risk[21].

The SSE must ensure risk management records are kept at the operation until the hazard is no longer present[22].

3.5.2 Risk monitoring records

Risk monitoring records need to be kept for 30 years

The SSE shall ensure that records of monitoring conducted in relation to a hazard with a cumulative or delayed effect, such as respirable dust and RCS, are kept for 30 years.

The records of monitoring include:

- medical record of workers made prior to their employment and in the course of their assessment
- workers' health assessment reports and health surveillance reports
- employment record of the workers
- exposure monitoring records for workers
- any workgroups or SEGs identified.

The records may be retained either as hard copy or electronically in a form that is readily accessible.

A black and white or greyscale-version of a colour record is acceptable if colour is not an important aspect of a document.

Risk monitoring records need to be kept secure

The SSE must ensure that any archiving system used maintains confidentiality and security of the records.

Prior to the operation ceasing operation, the SSE shall ensure that records of monitoring are securely archived and stored in accordance with directions from the chief inspector of mines.

[21] MQSHR section 10(2) Risk management record
[22] MQSHR section 10(3) Risk management record

Appendix 1 – Abbreviations and units of measure

Abbreviations

AIOH	Australian Institute of Occupational Hygienists
AQF	Australian Qualifications Framework
COPD	Chronic Obstructive Pulmonary Disease
OEL	Occupational Exposure Limit
GSD	Geometric Standard Deviation
MDLD	Mine Dust Lung Disease
MSHAC	Mining Safety and Health Advisory Committee
MQSHA	Mining and Quarrying Safety and Health Act 1999
MQSHR	Mining and Quarrying Safety and Health Regulation 2017
MVUE	Minimum Variance Unbiased Estimate
OEL	Occupational Exposure Limit
RCS	Respirable Crystalline Silica
RPE	Respiratory Protective Equipment
RSHQ	Resources Safety & Health Queensland
SEG	Similar Exposure Group
SHMS	Safety and Health Management System
SSE	Site Senior Executive
TWA	Time Weighted Average
UCL	Upper Confidence Limit

Units of measure

mg/m^3	milligrams per cubic metre of air
mm	millimetre
µm	micron or micrometre; $1 \text{ micrometre} = \frac{1}{1{,}000} \text{ millimetre}$

Appendix 2 – Glossary of terms

Breathing zone	A hemisphere of 300 mm radius extending in front of the face and measured from the mid-point of a line joining the ears.
Chronic obstructive pulmonary disease (COPD)	COPD is characterised by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and associated with an abnormal inflammatory response of the lungs to noxious particles or gases, including tobacco smoke, airborne dust particles, pollution, and infectious diseases. The two main forms are chronic bronchitis and emphysema.
Exceedance for Individual	When the measured time weighted average (TWA) of a worker's exposure to a hazard is above the shift-adjusted occupational exposure limit (OEL).
Exceedance for SEG	When the SEG Land's $UCL_{95\%}$ is above the shift-adjusted exposure limit for a hazard (determined after statistical analysis of the SEG exposure data).
Health Surveillance	The monitoring or testing of a person to check for changes in the person's health because of exposure to a hazard.
Land's Upper Confidence Limit (UCL)	Land's calculation of exposure assessment determines the upper and lower bounds of the Minimum Variance Unbiased Estimate (MVUE) to a 95% certainty. Hence in the interpretation of SEG data, there is a 95% certainty that the MVUE is below Land's UCL for that dataset (See **Appendix 5**).
Mine Record	Information that must be retained by the operator including: reports of inspections and investigations, audits, directives issued and remedial action, reports about all serious accidents and high potential incidents and all other reports or information that may be prescribed under a regulation[23]. Further guidance about mine records is provided in QGN05 Guidance Note on Keeping and Using the Mine Record at Mining and Quarrying Operations in Queensland.
Monitoring	A program or strategy that uses sampling to estimate workers' exposure or assessing the magnitude of dust levels.
MVUE	An unbiased estimate of the true arithmetic mean (AM) of a log normal dataset. The MVUE is especially useful when a dataset is heavily influenced by high results.
Pneumoconiosis	Pneumoconiosis is a general term given to any lung disease caused by dusts that are

[23] MQSHA section 59 Mine record

<table>
<tr><td></td><td colspan="2">breathed in and then deposited deep in the lungs causing damage.

Pneumoconiosis can develop when respirable airborne dusts, particularly mineral dusts, are inhaled. The dust particles remain in the lung where they can cause inflammation or fibrosis (scarring). The effects of damage from inhaled mineral dusts may not show up for many years, so workers may not develop symptoms until many years after they are no longer exposed to these dusts. The most common causes of pneumoconiosis are inhalation of asbestos, rock dust, silica containing dust or coal dust. Only some workers exposed to these dusts will develop pneumoconiosis.</td></tr>
<tr><td>Respirable Fraction</td><td>The proportion of airborne particulate matter that penetrates to the unciliated airways when inhaled. This fraction is further described in ISO 7708 as the percentage of inhalable matter collected by a device conforming to a sampling efficiency curve that passes through the points shown in Table 1 – Respirability of dust by particle size.

Alternatively, it can be described by a cumulative log-normal distribution with a median equivalent aerodynamic diameter of 4.25 µm and a geometric standard deviation of 1.5 µm.</td><td>Table 1 - Respirability of dust by particle size

<table><tr><th>Equivalent aerodynamic diameter (µm)</th><th>Respirability (%)</th></tr><tr><td>0</td><td>100</td></tr><tr><td>1</td><td>100</td></tr><tr><td>2</td><td>97</td></tr><tr><td>3</td><td>80</td></tr><tr><td>4</td><td>56</td></tr><tr><td>5</td><td>34</td></tr><tr><td>6</td><td>20</td></tr><tr><td>7</td><td>11</td></tr><tr><td>8</td><td>6</td></tr><tr><td>10</td><td>2</td></tr><tr><td>12</td><td>0.5</td></tr><tr><td>14</td><td>0.2</td></tr><tr><td>16</td><td>0.1</td></tr><tr><td>18</td><td>0.0</td></tr></table></td></tr>
<tr><td>Respiratory hazard</td><td colspan="2">Hazard with the potential to cause injury or illness to a person’s respiratory system. Respirable hazards typically found in a mineral mine or quarry include respirable crystalline silica and other airborne dusts, particulates, fibres, asbestos, welding fumes and diesel exhaust emissions.</td></tr>
<tr><td>Sampling</td><td colspan="2">The process of collecting a measurement or series of measurements of worker exposure.</td></tr>
<tr><td>Significant change</td><td colspan="2">Any modification or change of process or equipment that has the potential to alter worker exposure to a respirable dust hazard. Examples of significant change include:

• changing the nature of operations, for example, from exploration to extraction and processing, transition to care and maintenance, rehabilitation or closure;
• changing from an open cut to an underground mine;</td></tr>
</table>

	• changing mining method, for example open-stopping to block cave; • expansion of a pit operation from the original design; • upgrading or installing fixed plant (this may include new crushers or mills); • replacing or introducing mobile plant; • reduction or downsizing of operational activities.
Silicosis	A form of lung disease resulting from occupational exposure to silica dust over a period of years. Silicosis causes slowly progressive fibrosis (scarring) of the lungs and impairment of lung function. Workers with silicosis have a tendency to acquire tuberculosis of the lungs and an increased risk of lung cancer.
Similar Exposure Group (SEG)	Group of workers who have the same general exposure to risk. (e.g. the same similarity and frequency of the tasks they perform; the materials and processes with which they work; or the similarity of the way they perform those tasks).

Appendix 3 – Sampling methods and strategies

Quantitative risk assessment sampling strategy

<table>
<tr><th>Element</th><th>Requirement</th></tr>
<tr><td>Similar Exposure Groups.</td><td>SEGs should be based on logical associations, examples of SEG structure includes:
work or functional groups;
physical location;
activity;
equipment used.
The effective selection and use of SEGs may reduce the number of exposure monitoring samples that need to be collected for the assessment of the respirable dust risk.</td></tr>
<tr><td>Minimum number of workers to be sampled (based on size of workgroup or SEG).</td><td>Table 2 identifies the minimum number of samples required to enable reliable statistical analysis of a workgroup or SEG's exposure to be undertaken. Using the sample sizes in Table 2, an occupational hygienist can state with 90% confidence that at least one worker from a workgroup or SEG will be in the top 10% of exposures in the group.
<table>
<tr><th>No. of workers in group</th><th>Samples to be Taken</th></tr>
<tr><td>≤6</td><td>6</td></tr>
<tr><td>7</td><td>7</td></tr>
<tr><td>8-9</td><td>8</td></tr>
<tr><td>10</td><td>9</td></tr>
<tr><td>11-12</td><td>10</td></tr>
<tr><td>13-14</td><td>11</td></tr>
<tr><td>15-17</td><td>12</td></tr>
<tr><td>18-20</td><td>13</td></tr>
<tr><td>21-24</td><td>14</td></tr>
<tr><td>25-29</td><td>15</td></tr>
<tr><td>30-37</td><td>16</td></tr>
<tr><td>38-49</td><td>17</td></tr>
<tr><td>50</td><td>18</td></tr>
<tr><td>50+</td><td>22</td></tr>
</table>
Table 2 - Minimum sample numbers for statistical analysis of a workgroup or SEG[24].</td></tr>
<tr><td>Type of sampling</td><td>Only personal samples collected in a workers' breathing zone are to be used for quantitative risk assessment and periodic samples. To remove doubt, static sampling is not to be used for quantitative risk assessment and periodic samples.</td></tr>
</table>

[24] Leidel, Busch, & Lynch (1977)

Element	Requirement
Selection of workers to be sampled.	Workers to be sampled should be randomly selected on the day.
Sampling duration	The sampling duration should span the full shift. If this is not possible, the sampling duration shall be as long as possible but not less than half the shift duration (that is, not less than 4 hours for an 8 hour shift or 6 hours for a 12 hour shift).
Non-standard shift length or work-cycle	See **Appendix 6** of this Guideline.

Table 3 - Quantitative risk assessment sampling strategy

Periodic monitoring sampling strategy

Element	Requirement
Similar Exposure Groups.	SEGs should be based on logical associations, examples of SEG structure includes: • work or functional groups; • physical location; • activity; • equipment used. The effective selection and use of SEGs may reduce the number of exposure monitoring samples that need to be collected for the assessment of respirable dust.
Minimum number of workers to be sampled (based on size of workgroup or SEG).	The number and frequency of samples required for each workgroup or SEG shall be determined in accordance with Table 4 or as directed by an inspector of mines.

% Exposure	Samples per time period
>100	1 per quarter
50 to 100	2 per year
10 to 49	1 per year
<10	Professional Judgment

Table 4 - Periodic exposure monitoring - minimum sampling and frequency[25]

[25] Adapted from Grantham & Firth (2014).

Element	Requirement
	For the purposes of calculating % Exposure the following formula must be used: $$\%\ \text{Exposure} = \frac{\text{group data MVUE}}{\text{OEL}} \times 100$$ The occupational hygienist shall modify the periodic monitoring plan to include additional samples for workgroups or SEGs that have high variations in their respirable dust exposure, where the geometric standard deviation (GSD) of the group data is greater than 3. If the occupational hygienist determines that the Limit of Detection is greater than 10% of the exposure limit applying to workers, professional judgement should be used.
Type of sampling	Only personal samples collected in a workers' breathing zone are to be used for quantitative risk assessment and periodic samples. To remove doubt, static sampling is not to be used for quantitative risk assessment and periodic samples.
Selection of workers to be sampled.	Workers to be sampled should be randomly selected on the day.
Sampling duration	The sampling duration should span the full shift. If this is not possible, the sampling duration shall be as long as possible but not less than half the shift duration (that is, not less than 4 hours for an 8 hour shift or 6 hours for a 12 hour shift).
Non-standard shift length or work-cycle	See **Appendix 6** of this Guideline.

Table 5 - Periodic monitoring sampling strategy

Methods

Activity	Standard or method	Competency or accreditation
Calibration of sampling equipment	AS 2985 -Workplace atmospheres -Method for sampling and gravimetric determination of respirable dust.	Occupational Hygienist or Occupational Hygiene Technician (See **Appendix 4**).
Collecting respirable dust samples		Occupational Hygienist or Occupational Hygiene Technician (See **Appendix 4**).

Activity	Standard or method	Competency or accreditation
Respirable dust analysis		Third party technical accreditation (for example, NATA).
Respirable crystalline silica analysis	To be determined by an occupational hygienist in consultation with an analytical laboratory.	Third party technical accreditation (for example, NATA).

Table 6 - Sampling method requirements

Appendix 4 – Competencies

Occupational Hygienist

To conduct exposure assessment and respirable dust sampling an occupational hygienist must:

- be recognised as a Full Member of the Australian Institute of Occupational Hygienists (MAIOH); or
- hold an equivalent competency under an international certification scheme (for example - Certified Industrial Hygienist); or
- hold an Australian Qualifications Framework (AQF) Level 8 or above qualification (i.e. bachelor honours degree, graduate certificate, graduate diploma, masters degree, or doctoral degree) in occupational hygiene with a minimum of 5 years' experience in the field of occupational hygiene.

Occupational Hygiene Technician

To conduct dust respirable dust sampling, an occupational hygiene technician must have completed the competencies recognised by the Mining Safety and Health Advisory Committee for the task (www.rshq.qld.gov.au/resources/documents/commissioner/recognised-mining-competencies.pdf).

Sampling conducted by an occupational hygiene technician must be done under the supervision of an occupational hygienist with competencies described above.

Appendix 5 – Descriptive statistics of exposure data

Statistical analysis provides descriptive statistics to assist with the analysis of exposure[26].

The occupational hygienist shall review the validity of exposure monitoring results older than 2 years for inclusion in the statistical analysis.

The Minimum Variance Unbiased Estimate (MVUE) is an estimate of the mean exposure for the group or SEG. The accuracy of the estimate may be improved with increased number of samples. However, the potential range of values for the true mean exposure may evaluated. Land's calculation of the confidence limits determines the upper and lower bounds of possible mean exposure for the dataset.

Where the data collected is found to not be lognormal or the majority of samples are below the limit of detection, then another statistical technique or professional judgement should be used by the occupational hygienist to assist with the analysis of exposure.

Statistical Measure	**Description**
Number of samples (n)	At least 6 samples are required to perform statistical analysis of a data set. Number of samples required for statistical assessment of the SEG should be based on the estimate of exposure and the number of workers in the workgroup or SEG; Table 2 must be used as guidance on sampling numbers required statistical analysis.
Minimum (min) / Maximum (max)	Describes the range of exposure values in a given data set for a SEG.
Minimum Variance Unbiased Estimate (MVUE)	The estimated average exposure of the SEG for a lognormal population. This datum may also be referred to as the Estimated Arithmetic Mean (est. AM).
Lands Upper and Lower Confidence Limits 95% Upper Confidence Limit (UCL)	Land's calculation determines the error boundary of the MVUE to a 95% certainty. In the interpretation of the respirable dust risk to a SEG, it is certain (to 95% confidence) that the MVUE will not be greater than the upper confidence limit (UCL). If SEG's Lands UCL is below the OEL, the SEG exposure may be considered acceptable.

[26] Only personal samples collected in a workers' breathing zone in accordance with the applicable sampling methods and strategies stated in Error! Reference source not found. are to be used for descriptive statistics. To remove doubt, s tatic samples or real-time samples are not to be used for descriptive statistics.

Statistical Measure	Description
Geometric Standard Deviation (GSD)	A measure of the spread of data in a dataset. It is expected that most exposures in a SEG are generally the same. Where there is significant variation in a dataset, this will be reflected by the value of the GSD (See Table 8). High GSD values may indicate a need to undertake additional sampling or to review the accuracy of the SEGs definition.

Table 7 - Descriptive statistics

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 data set – potentially due to: • elevated individual exposure results; • samples below the limit of reporting; • insufficient number of samples.
>3.0	Significant variation in data set – potentially due to: • Significant outliers in data set; • Incorrectly defined SEG; • Insufficient number of samples.

Table 8 - Interpreting the GSD

Appendix 6 – Adjustment of the OEL for non-standard work cycles

The occupational hygienist must ensure that the occupational exposure limit (OEL) for a respirable dust hazard is adjusted, where appropriate, for non-standard work cycles.

Supporting information for the adjustment of the OEL is provided in the AIOH document *'Adjustment of Workplace Exposure Standards for Extended Work Shifts'* with further reference to the spreadsheet utilising the Quebec Model for exposure adjustment.

In Table 8, the Quebec model was used to calculate the adjustment factor to the OEL. The application of the adjustment factor to other parameters may only be made after reference to the supporting information for the adjustment model.

Roster work cycle	**shifts worked in roster**	**number of days break in roster**	**hours per day**	**number of days in work cycle**	**number of hours worked**	**average number of hours per week**	**adjustment factor**
7 on/7 off - 12.5 hour days	7	7	12.5	14	87.5	43.75	0.91
4 on/3 off - 12 hour days	4	3	12	7	48	48	0.83
10 hour days, 5 day workweek	5	2	10	7	50	50	0.8
14 on/7 off	14	7	12	21	168	56	0.71
8 on/6 off - 12.5 hour days	8	6	12.5	14	100	50	0.8
short work week	4	3	7.2	7	28.8	32.4	1

Table 9 - Adjustment factor to an OEL for typical non-standard work cycles in mining

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