Silica – Technical guide to managing exposure in the workplace

Work-related disease strategy 2012-2022

Queensland Government

Contents

Introduction

Silica has been a long standing health hazard, causing millions of cases of disease and death since civilisation, stone masonry and mining began. The risk arises through the inhalation of dusts containing crystalline silica. This document will assist workplaces where silica is present to manage the risk to workers' health.

The workplace health and safety law has provision that employers or persons conducting a business or undertaking (PCBU) must control the risks from silica exposures.

This document provides guidance on dealing with silica exposures in non-mining environments by drawing from the relevant documents listed below to link together the information important to silica. The guidance is topic specific and not industry specific. Of the legislative and guidance instruments available, several have specific reference to silica. These are denoted by an asterisk*.

Workplace Health and Safety Queensland:

- Work Health and Safety Act 2011
- Work Health and Safety Regulation 2011 (particularly Chapter 3 – General risk and workplace management and 7.1 – Hazardous Chemicals)
- Foundry Code of Practice*
- Abrasive Blasting Code of Practice*
- Managing respirable crystalline silica in the stone benchtop industry Code of Practice*
- Managing respirable dust hazards in coal-fired power stations Code of Practice*
- How to Manage Work Health and Safety Risks Code of Practice 2011
- Preparation of Safety Data Sheets for Hazardous Chemicals Code of Practice
- Managing Risks of Hazardous Chemicals in the Workplace Code of Practice Labelling of Workplace Hazardous Chemicals Code of Practice

Safe Work Australia:

- Hazardous Chemicals Information System*
- Workplace Exposure Standards for Airborne Contaminants*
- Guidance on the interpretation of workplace exposure standards for airborne contaminants*
- Guide for Tunneling work

Standards Australia:

- Australian/New Zealand Standard 1715:2009 Selection, Use and Maintenance of Respiratory Protective Equipment
- Australian Standard 2985:2009 Workplace Atmospheres - Method for sampling and gravimetric determination of respirable dust

What is silica?

Approximately half the composition of earth's crust is silicon dioxide with the chemical formula SiO_2. At the workplace, silicon dioxide may occur both in its crystalline form or combined with other minerals or materials. There are five different forms of free silica, but the one predominantly found in workplaces is quartz, the same basic material found in sand. Silica is a generic term commonly used to refer to crystalline silica, including crystalline quartz.

Two other forms of crystalline silica may occasionally be found, but only one is significant to workplaces. This is cristobalite, and can be found where heating of quartz containing materials occurs. Cristobalite also sometimes enters workplaces in filtering products prepared from heated silica or diatomaceous earth, or appears in foundries where quartz is affected by red hot metal. A third form, tridymite, requires very high heat for its formation and would be unexpected in workplaces.

For this technical guidance material, we refer variously to silica, free silica but mostly to respirable crystalline silica (RCS).

Do risks from silica still exist in workplaces?

The major risks previously observed in silica-exposed populations have been greatly diminished over the last five decades; however, thousands of workers are still potentially at risk from exposure.

Silica remains an important risk factor for respiratory disease. Respiratory disease is a work-related disease in focus for recognition, prevention and management with Safe Work Australia. This has been taken up as a priority in Workplace Health and Safety Queensland's Work-related *Disease Strategy 2012-2022.* Workplace exposure to crystalline silica permitted by regulation is very small.

Why does respirable crystalline silica represent a workplace hazard?

Silicosis

The basic concern about quartz or RCS is that it is toxic to the human body in several ways. Principally it is fibrogenic (promoting the development of fibrous tissue) to the lung causing silicosis.

It is the silica dusts, mostly smaller than10 µm in diameter, that are potentially damaging to the lung. This size range cannot be seen by the naked eye in ordinary lighting. That fraction of a dust cloud which penetrates to the alveolar space of the lung is referred to as the respirable fraction. The respirable fraction of a dust cloud must be measured to assess the disease risk from dusts containing RCS. Size and surface area of particles are important determinants of their toxicity but are not specifically measured.

The International Organisation for Standardisation (ISO) penetration curve (Figure 1) used to define the concept of respirability shows that particles of <1 µm aerodynamic diameter will mostly all penetrate to the lung, whereas most particles >10 µm will be deposited before reaching the lung.

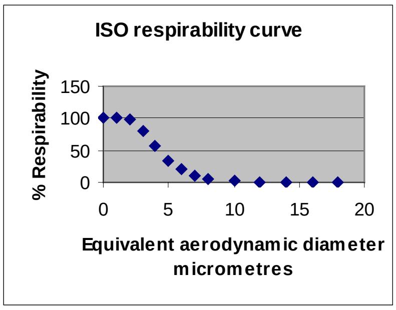
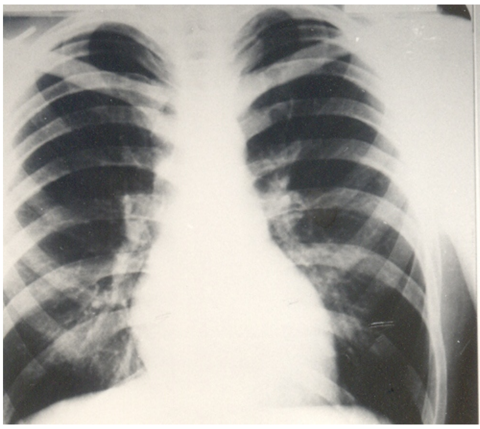


Figure 1: ISO penetration curve for respirability
1 µm = micrometre. Human hair = 17 – 150 µm

Why crystalline silica promotes fibrogenic disease, principally silicosis, is not entirely clear, although it may be linked to the electronic structure of the surface of free silica crystals in promoting cellular release of free radicals. Its toxic effect on cells (cytotoxicity) also appears to be dependent on the age of fractured crystalline silica, decreasing with time after cleavage. The respiratory system's clearance and defence mechanisms cannot cope with the deposited silica dust which, after a long latency period, can lead to the formation of fibrous tissue and reduced lung capacity. Not all workers who are exposed to silica will develop respiratory disease. Diseases from RCS exposure may take up to several decades to develop.

Silicosis can range from a mild non-disabling simple silicosis (X-Ray visible) category. Figure 2 shows clear lung fields whilst Figure 3 shows advanced silicosis.



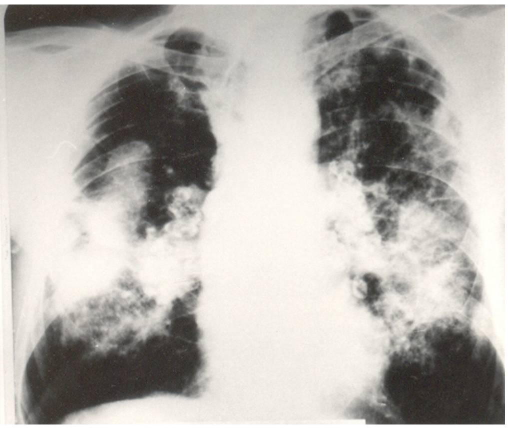


Figure 2: Clear lung fields

Figure 3: Silicotic lungs

Other diseases

Studies on various populations, usually those working with exposure to high concentrations of silica over their working lives, have found evidence for carcinogenicity of inhaled RCS. The International Agency for Research on Cancer found in 1997 that there is sufficient evidence to conclude that crystalline silica from occupational sources is carcinogenic. However, increase in lung cancer appears associated only amongst those with silicosis. Prevention of silicosis should also then prevent silica-related lung cancer.

Lung and bronchogenic cancer are also caused in large part in the community by smoking. It is then prudent to ensure that exposures to RCS are always controlled well within the exposure limits (see below for this information) which is known to control silicosis.

Exposure to RCS also shows evidence for causing various obstructive lung disorders, such as chronic bronchitis and emphysema. Exposure to RCS is also observed to result in decreased respiratory volumes. Silica does not cause asthma. Some of those exposed long term to silica have also shown autoimmune disease and renal disease, though their excess is small.

Not all workers who are exposed will develop any one of these diseases, as there will be biological and genetic factors (most not fully understood) governing the development of disease in an individual.

What kinds of workplaces and processes expose workers to silica?

Industries

Because silica is widely encountered in extractive industries, in the manufacture of many concrete based building materials, and finds widespread use in manufacturing processes, the number of Queensland workers potentially exposed is large. Typical leading industries include:

- tunnelling
- foundries
- stonemasonry
- cement manufacturing
- power generation
- brick and tile manufacturing
- ceramics
- construction, including granite grinding and polishing
- metal polishing
- architectural abrasive blasting
- quarrying
- mining.

Processes

Any process using materials containing quartz that produces fine dust has the potential to expose workers to RCS. The following illustrations (Figures 4 to 8) show typical industries and tasks which could expose workers to dusts containing RCS.

Figure 4: Major earthworks/mining

Figure 5: Brick making

Figure 6: Concrete block cutting

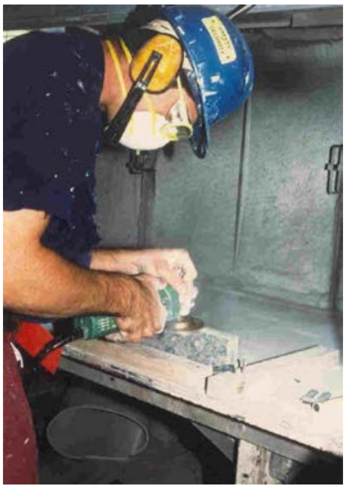


Figure 7: Granite grinding

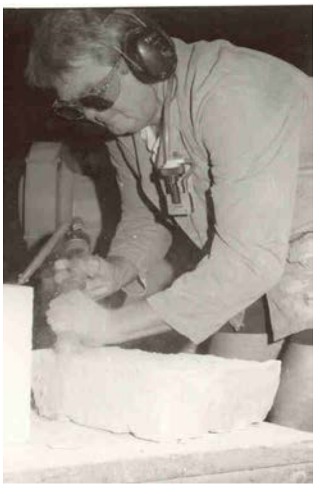


Figure 8: Stone masonry

What does the legislation say about working with silica?

Work Health and Safety Act 2011

The *Work Health and Safety Act 2011* (WHS Act) establishes a number of primary duties for a PCBU. Under section 19, the PCBU has a duty to ensure the workplace health and safety of various persons.

This duty is paramount. In other words, if a PCBU is involved in work with materials involving silica exposure, so far as is reasonably practicable, no person's health is to be affected by that work.

Section 19 duties as they apply to the use of silica in the workplace include:

- providing and maintaining safe and healthy work environment
- providing and maintaining safe plant and structures for working with materials containing silica
- ensuring safe systems of work
- ensuring safe use of silica containing substances
- providing information, instruction, training and supervision
- ensuring the workplace conditions are monitored to prevent illness from carrying out work with silica.

At this umbrella level of the WHS Act, there is no specific mention of silica. Significant specific detail relating to silica is found in documents such as the Foundry Code of Practice, the Abrasive Blasting Code of Practice, the Managing respirable crystalline silica in the stone benchtop industry Code of Practice and the Managing respirable dust hazards in coal-fired power stations Code of Practice and the Workplace Exposure Standards and their guidance.

Work Health and Safety Regulation 2011

Silica became subject to partial regulation as a hazardous substance in Queensland in 1995. The Work Health and Safety Regulation 2011 (WHS Regulation) has a universal coverage to address all situations where silica is encountered in workplaces, whether it is supplied as a hazardous chemical with a safety data sheet (SDS) or it is generated as a hazardous substance from a process from existing materials in the workplace.

All products intended for workplace use which contain crystalline silica and are classified as hazardous chemicals will be included. Therefore all the relevant sections relating to labelling and SDSs will apply. Typically, then, sand or cement materials must be considered as hazardous chemicals for the purpose of the WHS Regulation.

Where the silica is incorporated into a product with a formed shape (e.g. a tile, a concrete block or a cement board) which may be worked and so create a silica containing dust, the PCBU needs to be aware of the existence of the hazard in the product, whether it is labelled or not. The WHS Regulation will apply equally to the silica dust generated in those circumstances.

The remaining part of this document is directed to all the different aspects of the WHS Regulation that a PCBU has to address when working with silica as a hazardous chemical or a hazardous substance with extensive guidance provided on what a PCBU can do to comply with the regulatory duties.

Many of the regulatory duties, though not all, carry legislative penalties for non-compliance.

What are the important things for a PCBU to do?

WHS Regulation Chapters 3 and 7.1

The specific activities which a PCBU must carry out with respect of silica are found in two distinct areas of the regulation.

WHS Regulation No	Major activity
34	Identifying the silica hazards
341	Labelling hazardous chemical containers
344	Obtaining, recording and displaying SDS
346	Keeping a register of hazardous chemicals
35	Managing the risk
44	Providing personal protective equipment
49	Ensuring exposure standards are not exceeded
50	Monitoring workplace air for silica
368-377	Health monitoring for exposed workers
50	Keeping air monitoring records
378	Keeping health monitoring records
38 and 352	Reviewing control measures for silica
379	Induction, information, training and supervision about silica.

The process devised below in Steps 1 to 8 has been determined to be appropriate for workplaces with silica exposure. It follows a logical stepwise application of the eight basic requirements of the WHS Regulation in the sequence a PCBU would implement them, not in the numerical order they appear in the WHS Regulation.

Step 1: Identify silica through a safety data sheet, a label or other sources

WHS Regulation 34 on identifying that you may have a silica hazard

The process of identifying hazardous chemicals usually relies on using the safety data sheet (SDS) and a product label. Silica containing materials supplied and brought into workplaces need to be accompanied by both the SDS and the label. Manufacturers and suppliers of a product containing silica have the duty to provide the SDS and label for use by the PCBU.

What does the SDS provide to the PCBU?

The SDS will provide necessary information on identity, health effects and safe use to assist the PCBU to conduct the risk management process.

In those instances previously mentioned where an SDS is unlikely to be provided, alternative sources must be sought to obtain information about possible risks from silica. The instances include:

- drilling rock for a building foundation
- chasing in a concrete wall
- concrete floor grinding
- concrete block cutting
- tunnelling for an underground roadway.

Sections 341 - 346 Labelling of containers, safety data sheets and the hazardous chemicals register

These sections of the WHS Regulation contain a set of simple administrative requirements relating to how information regarding the silica is to be obtained, stored and used in the workplace.

As far as silica containing chemicals are concerned, **labelling** is no less of a priority than for other chemicals, despite the difficulty of labelling a lot of product which is used in bulk form. However, most of the labelling requirements for silica derived from sand are simple. Some specialty products such as abrasive blasting agents with intentionally low levels of silica will undergo careful and deliberate labelling. Pipe work used for pneumatic conveying of dry sand is an example requiring pipe work labelling.

Section 344 Obtaining, recording and displaying an SDS

Besides identifying the existence of silica, information from the SDS is important for informing decisions about health risks. For these reasons, separate duties with respect to SDS have been specifically determined. To ensure that information ***is*** obtained, and is accessible by the ultimate user:

- the workplace must obtain the current SDS from the supplier
- a copy of the current SDS must be placed in the register of hazardous chemicals
- a copy of the SDS must be kept close enough to where the silica is being used by a worker for their easy reference (this assists the worker in identifying the silica hazard, being informed about the hazard and complying with appropriate controls).

WHS Regulation 346 Keeping a register of hazardous chemicals

The register is essentially a repository where the names and details of all the hazardous chemicals used in the workplace are recorded. SDS of chemicals containing crystalline silica need to be stored in this register. Examples would include cements, silica containing grouts, tripoli polishing blocks, calcined diatomaceous earth filtering powders, sand supplied for moulding and concrete product manufacture, some blasting abrasives, silica polishing powders and some materials used in manufacturing dental prostheses.

This register must be readily accessible by those who use, store or handle the silica containing chemicals.

Step 2: Managing the risk

WHS Regulation section 35

Managing the health and safety risk from operations involving crystalline silica commences with an assessment of information in the SDS or other technical information where no SDS is likely to be present. Because silica has such a central role in products related to construction, extractive industries, metal production and metal working, elimination of all risk associated with silica is impractical in most situations.

Management of silica related risk is thus reduced to one of minimising the risk of exposure to dusts containing RCS. This is usually achieved by ventilation and use of respiratory protection, or a combination of these.

WHS Regulation section 49

Workplaces can present RCS risks ranging from trivial exposures to life threatening. An SDS, if available, will provide information about the health hazard, the workplace exposure standard (WES) and some suggestions for controlling the exposure, but it will not demonstrate what is happening in the workplace. It is possible to manage the risk using qualitative information from the SDS about controls, from the label and from knowledge about the processes where RCS is generated in the workplace.

Experience has shown, however, that managing the risk may require demonstrating that no person is exposed to a substance (RCS) in an airborne concentration that exceeds its exposure standard.

What is the workplace exposure standard for respirable crystalline silica, and where to find it?

According to the Safe Work Australia definition, (the) **‘***Exposure standard represents the airborne concentration of a particular substance or mixture that must not be exceeded’*. Section 49 of the WHS Regulation uses this exposure standard as a means to pursue the goal of preventing adverse health effects.

The WHS Regulation establishes a minimum standard for exposure to dusts containing RCS where the exposure cannot be prevented. In this case, the relevant exposure standard for dusts containing quartz, cristobalite or tridymite which cause chronic disease is the 8 hour Time Weighted Average Exposure Standard (TWA-ES) of 0.05 mg/m^3 measured as RCS in the respirable dust portion of a dust cloud. This RCS standard is expressed in accordance with the previously mentioned ISO convention for respirable dust sampled as is mentioned in Step 3.

It should be noted that the TWA-ES of 0.05 mg/m^3 applies to a standard 8 hour working day. If your work shift is longer than 8 hours, it is necessary to make some downward adjustment in the exposure standard. This is to allow for both the extended period of work exposure and the diminished amount of time for recovery and clearance mechanisms to operate between consecutive shift exposures. Guidance for making this adjustment for extended shifts is provided in the Safe Work Australia *Guidance on the interpretation of workplace exposure standards for airborne contaminants* using an appropriate model (e.g. using the conventional Brief and Scala shift adjustment model, for a 10 hour work shift, the TWA-ES for RCS is reduced to 0.035mg/m^3, and for a 12 hour work shift, it is reduced to 0.025 mg/m^{3*}). The PCBU should seek professional guidance from an experienced occupational hygienist on the most appropriate shift adjustment model where extended shift operations involving RCS occur.

* mg/m^3 = milligrams per cubic metre of air

Step 3: Monitoring workplace air for RCS

WHS Regulation Section 50 may require that monitoring for the RCS be undertaken. If the PCBU’s risk management program has determined that a worker is exposed to RCS but does not know whether the RCS exposure is above or below the exposure standard, then the worker’s exposure should be monitored.

The need for such airborne monitoring of RCS can usually be restricted to workers who do not use respiratory protection. If workers consistently use an appropriate level of respiratory protection, exposure will probably be controlled and air monitoring may be unnecessary.

Monitoring for RCS:

- provides information about RCS exposure for those workers who work without respiratory protection and need to have those exposures maintained well below the WES
- indicates compliance or otherwise with the WHS Regulation
- provides a guide to the potential risk to health
- helps determine the appropriate control strategy required (e.g. substitution, ventilation or use of respiratory protection, or combinations of these), where non-compliant exposures are identified
- can be used to determine the correct minimum protection factor for respiratory protection (see Step 4 for details).

How is monitoring for RCS carried out?

Monitoring of exposure for RCS requires sampling the atmosphere as a personal dust sample which accompanies a worker as they conduct their work typically over a shift. The collected sample undergoes laboratory analysis for both respirable dust concentration and RCS concentration. The sampling for dust in the workplace is carried out in accordance with *Australian Standard 2985:2009 Workplace Atmospheres - Method of sampling and gravimetric determination of respirable dust.*

The worker wears a dust sampling device (called a vertical cyclone elutriator – see Figure 9 below) on the shirt lapel for a period of 6 to 8 hours (or longer if practicable) during the work shift. Dusty air is drawn through the sampling device by a small, portable, battery powered pump. The vertical elutriator separates out the respirable fraction of the dust which corresponds to that fraction of a dust cloud which will penetrate to the alveolar oxygen exchange part of the human lung. Sampling must be undertaken in what is referred to as the breathing zone of the worker, generally within 300 mm of the nose and mouth. Sampled dust is usually assessed for its respirable dust concentration, and also for its RCS concentration which is determined by infrared spectroscopy or X-ray diffraction analysis.

Because of environmental and workplace task variability, repeat sampling may be required to gain a better idea of likely exposure, and the likelihood of compliance with the regulatory exposure standard.

Monitoring for RCS can be expensive, so it should be undertaken judiciously. Where workers are potentially exposed to RCS and there is neither specific engineering control (e.g. ventilation or isolation) nor use of respiratory protection, then the risk management process is likely to require some monitoring. The naked eye cannot normally see respirable dust, particularly if present with other larger non-respirable dusts, so the eye thus cannot judge dust concentrations. Dust may be visualised, but not measured, by use of a Tyndall light scattering dust lamp. As the WES for RCS is very stringent, and the composition and concentration of the dust cloud will be unknown, the only reliable way to assess the risk from RCS will be through monitoring.

Only large workplaces with significant resources or those with specialist in-house expertise will be able to conduct their own silica monitoring. Most monitoring is conducted by consultant laboratories, private consultants, or occasionally by Workplace Health and Safety Queensland Inspectors.

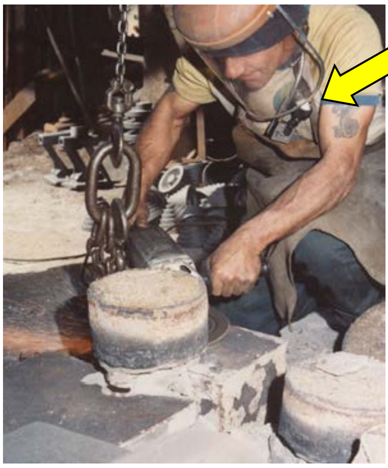


Figure 9: Foundry worker wearing elutriator suitable dust sampler in his breathing zone

Figure 10: DustTrak™ fitted with cyclone elutriator for static monitoring and checking of dust controls

Monitoring for respirable dust without silica analysis

Some direct in-situ monitoring for respirable dust can be undertaken, but it does not provide any data on RCS. Instruments such as a DustTrak™ (Figure 10) can provide some useful spot information about the efficacy of dust control devices, again useful for dusts unable to be seen by the naked eye. It is also suitable for measuring peak dust concentrations to gain an idea about the capacity of respiratory protective devices to meet minimum required protection factors in some operations with periods of peak dust production. To be consistent with the legislative needs, such devices should be fitted with a cyclone elutriator operating to the sampling efficiency curve specified in the *Australian Standard 2985:2009 Workplace Atmospheres - Method for sampling and gravimetric determination of respirable dust.*

Step 4: Selecting the means for controlling the risk

Section 35 of the WHS Regulation establishes the overall duty to manage risk, and section 49 establishes the performance standard to be met and section 36 outlines the steps which the PCBU must take to manage the risk.

Section 36 specifically requires that the duty holder to use the hierarchy of control measures when the risk from RCS cannot be eliminated. This implies that efforts have to be made to control the dust generated in a workplace, rather than accepting the dust as inevitable and concluding that personal protective equipment in the form of respirators is the most appropriate way to control the exposure to the silica.

Managing the risks of hazardous chemicals in the workplace Code of Practice details this hierarchy of control. Those of most importance to workplaces with potential RCS exposure are, in order:

- elimination
- substitution
- engineering controls, particularly isolation, enclosure and ventilation
- administrative controls
- personal protective equipment (respiratory protection).

Refer to Table 1 to gauge the usefulness of these strategies for control of RCS in the workplace. There is a number of strategies available ranging from controlling the dust being released into the workplace to the extreme of simply protecting the worker in an uncontrolled dusty environment. In all cases, the primary controlling goals are to minimise the exposure to silica and to ensure exposure is not greater than the workplace exposure standard (WES).

Commonly used controls

Table 1: Different kind of controls suitable for RCS

Control procedure	Usefulness in dealing with respirable crystalline silica dusts
Elimination	Often totally impractical when having to work natural products such as sand, concrete, clays, or processes such as tunnelling. Of some importance only if a process can be eliminated completely.
Substitution	Extremely advantageous when silica content of the materials being used can be reduced markedly. Examples include substituting ilmenite, garnet or staurolite for sand in abrasive blasting; using aluminium polishing powders instead of silica powders; replacing silica parting powders in foundry casting with non-silica ones. Processes can be substituted (e.g. using prilled solids rather than powders; changing from dry to wet processes; vacuuming rather than sweeping).
Engineering controls • containment	Most effective when the process obliges continued use of silica containing material. Has the particular advantage of preventing hazardous silica dusts from entering the workplace atmosphere so that other controls may not be required. May contribute to economic product recovery.
• ventilation	Highly effective when silica containing dust clouds cannot be completely contained at source because of the need for worker to work with the materials (e.g. mining, pouring, grinding, polishing, moulding, casting, blasting, fettling, mixing, bagging, crushing, drilling, chasing). Dusts are extracted close to the source. Has the advantage of preventing dusts whose generation cannot be avoided from spreading and contaminating other parts of the workplace. Is very cost effective in long term, particularly for fixed continuous processes where point source extraction can be organised, and in most cases, permits workers to operate freely with adequate levels of protection in the workplace unencumbered by use of respiratory protection.
• suppression	Water or fine mist suppression is also employed to control dust clouds which are not always amenable to use of fixed point ventilation. Some foundries utilise such systems. Water suppression is also used effectively in construction for brick, tile, stone and concrete cutting.
Administrative controls	Typically includes housekeeping, warning signage, but may include restricting the time of exposure, rotation of staff away from dusty areas.
Respiratory protection	Applicable and useful for short term applications when very expensive ventilation solutions are not warranted. Also very applicable where the source of dusts cannot be fully contained such as tunnelling, outdoors work, abrasive blasting or where particles are imparted with a velocity beyond the capture capability of ventilation systems. Finds application also when higher order controls have been applied but cannot fully control the risk. Should remain the means of last resort for permanent control of RCS. Applicable in all emergency applications.

Engineering controls

Engineering control is fundamental to the control of dusts produced in many workplaces (grinding, crushing, blasting, pouring, cutting, sanding.). Its major role is to prevent dust clouds produced by different processes from entering and grossly contaminating workplace air, thus exposing the worker and other nearby workers. Workers can be directly associated with these dusty processes using hand tools or machine processes.

Enclosure or containment processes isolate the worker from any contact with a dusty operation. An example is an abrasive blasting chamber (see Figure 12).

Ventilation

Ventilation remains the major tool for controlling dusts in the workplace. Ventilation is applied under those situations where dust is generated and cannot be prevented entirely from entering the workplace air. The purpose of ventilation is to provide a working environment which is not detrimental to the worker’s health. Removal of dust can be both health and housekeeping considerations. Dusts which contain significant amounts of RCS are typically risks to health and are often deleterious to amenities in the workplace such as equipment operation.

Ventilation is often the preferred method of control for dusts because it:

- permits continued worker access to machines and processes
- is the most economical in the long term
- has the greatest worker acceptability and does not interfere with worker mobility
- can be provided in many different forms.

Ventilation is available in three basic variants:

- natural ventilation
- forced dilution ventilation
- local exhaust ventilation (LEV).

Choice of type of ventilation as a control for dusts containing RCS will depend on:

- the specific task
- the concentration of RCS in the dust cloud
- whether the dust is generated as a diffuse or point source
- the amount of dust being generated
- the rate of generation of dusts (i.e. is it constant or highly variable).

Natural ventilation for controlling dusts containing RCS has some application in outdoor settings, and in large open buildings with large air volume, small amounts of dust being generated with low RCS content, or there is a very diffuse source of dust which cannot be easily captured. However, the vagaries of climatic conditions, wind direction and the toxicity of RCS means that natural ventilation often has to be supplemented with respiratory protection for adequate control.

Forced dilution ventilation with the use of fans or large air extraction systems is limited to indoor applications. Forced dilution ventilation is characterised by the movement of relatively large volumes of air at low pressure. Examples are a wall extraction unit, or roof ridge fans. Use of low pressure means that there is only limited capacity to influence the direction of air movement, and even less capacity to influence the direction of independently moving dust particles which might be generated by a mechanical process such as a powered hand tool. It has the same constraints as natural ventilation with the exception of improved air movement reliability.

Local exhaust ventilation (or LEV) is by far the most effective means of controlling large amounts of highly toxic contaminants such as dusts containing RCS arising from specific or point sources. In many situations, LEV can be designed and operated such that the equipment operator need not be fitted with respiratory protective equipment.

The illustrations below show (Figure 11) a pottery worker finishing (towing) pottery pieces inside a cabinet fitted with LEV. The worker does not require any respiratory protection despite large amounts of RCS contaminated dust being created in the process. The operator (Figure 12) is unloading a fully enclosable abrasive blasting chamber fitted with LEV to contain the extreme risk created by dust arising from the sand attached to the metal substrate.

Figure 11: Pottery worker using a cabinet fitted with LEV

Figure 12: Abrasive blasting with isolating cabinet fitted with LEV

LEV systems for capture of particulate dusts are relatively complex in design and operation. LEV systems consist of a capturing hood, ducting, a fan and a discharge which may include a filtration or capturing unit as well as direct discharge to air. In contrast to dilution ventilation, LEV uses low air volumes, higher air speeds, and a higher (negative) pressure - enough to influence the movement of independently moving particles, and maintain them in the moving air inside a duct).

Types of LEV

There are three types of LEV devices:

1. The enclosing hood - work is conducted inside an air space which can be fully enclosed, or open at the front for operator access. Dusty RCS contaminated air is drawn away from the operator via the exhaust system. Figure 11 shows an enclosing hood.
2. The exterior hood – the collecting hood is positioned next to, above or sometimes below the dust source. With the exterior hood, the airflow induced into the hood has to be sufficient to create a zone of negative pressure beyond the hood boundary. The hood (inlet to the exhaust system) has to be placed as close as possible to the dust source to effectively capture contaminated air. See example in Figure 13 A. Air velocity at 1 hood diameter from the hood will be ~10% the hood entrance velocity.
3. High velocity low volume hoods (HVLV) - these are specialised capturing devices attached directly to tools at the point where dust is created (Figure 13B).

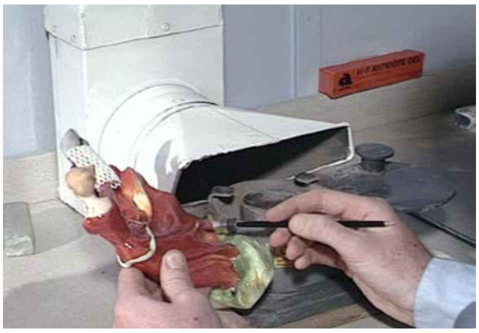


Figure 13A: Fixed exterior hood (HSE UK)

Figure 13B: Cutting concrete with HVLV extracted device (Source: Dustcontrol UK)

Design and testing ventilation

If the workplace requires LEV for controlling RCS dusts, the LEV will need to be designed for that application. With exterior hoods there are special considerations to be given to both the capture distance at which a hood will work effectively and the required capture velocity which is needed to capture different kinds of dusts. Exterior hoods generally work only over relatively small distances.

Ventilation systems require regular testing to ensure correct operation, as they are prone to developing leaks, filter blockages and failing fan performance. If the workplace uses a LEV system to control RCS dust, one of the two following simple devices can be used for testing both the air flow of the exhaust system and the capture velocity actually being produced with exterior hood:

Air current tubes – these tubes produce a white aerosol allowing visualisation of air flow (Fig 14)

Anemometer – whirling vane or a hot wire anemometer to measure actual air flow rates. (Fig 15)

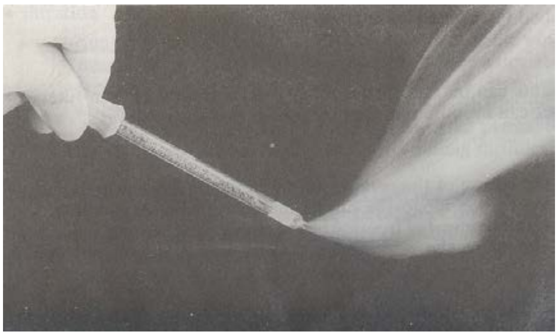


Figure 14: Air current tubes

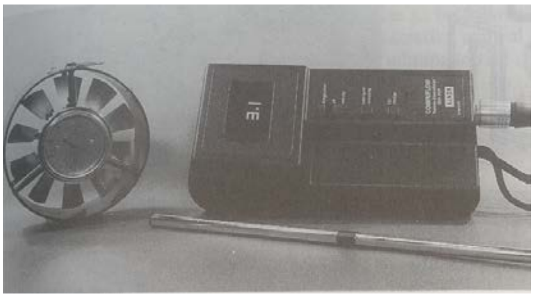


Figure 15: Whirling vane anemometer (l)
Hot wire anemometer (r)

Capture velocity

The following Table 2 can be used as a guide when testing the velocity at the capture point outside an exterior or capturing hood. Minimum air velocity (ventilation rates) will vary depending on the method in which the dust is being generated. The (air movement) extraction rate has to be measured at or near to the point of dust generation.

Table 2 Typical air flows required to capture differently generated dusts

Type of contaminant being generated	Air speed required m/s at point of capture	Inlet velocity if capture point is 1 hood diameter away m/s
Dusts from pouring operations	0.5 – 1	5 – 10
Crusher dusts	1 – 2.5	10 – 25
Grinding, blasting, high speed wheel generated dusts	2.5 – 10	25 – 100

Unlike respiratory protection, there is little readily available user advice which can be sourced relating to ventilation systems, their performance requirements, design or their testing.

Respiratory protection

Respiratory protective equipment (RPE) remains a widely used control measure for dusts containing RCS. In many workplaces higher order controls will not be feasible, or even when applied, will not prove to be completely effective (e.g. in tunnelling). Specialist safety suppliers are able to provide advice and a wide range of different respiratory protection devices against RCS according to the risk management needs.

WHS Regulation Section 36 makes reference to the situation where other controls have not worked and RPE has to be applied:

> *(5) If the risk remains, the duty holder must minimise the remaining risk, so far as is reasonably practicable, by ensuring the provision and use of suitable protective equipment.*

This requirement is expanded on in WHS Regulation Section 44. For the purposes of managing the risks of RCS, Section 44 is interpreted to addresses the matters of

- Who should provide the RPE
- Selecting the RPE so that it is fit for the purpose and the wearer
- Maintenance of the RPE so it continues to work
- Ensuring that the worker wears the RPE
- Providing the appropriate information and training to the worker on how to use and wear, store and maintain the RPE.

Respirators for regular applications involving RCS will need to be one of the following:

- particulate filter respirators
- supplied air respirators
- powered air purifying respirators.

Respiratory protection for use in workplaces can be adequately selected using *Australian/New Zealand Standard 1715-2009 Selection, use and maintenance of respiratory protective equipment.*

The performance capability of the respirator is determined by a combination of the type of face piece and the filter capacity for conventional negative pressure demand respirators. For supplied air respirators, the face piece defines the performance.

Which one you choose for your RCS will depend on the at least three important factors:

- the contaminant
- the task
- the operator.

For silica, the **contaminant** is known. RCS is known to present its risk primarily as a particulate of respirable dust, with a WES of 0.05 mg/m^3. If employing a conventional respirator, it will need to be a particulate respirator (P1, P2 or P3 filtering respirator) or an air supplied respirator. Nearly all dusts containing RCS will be mechanically generated.

The **task** takes into account what the worker is doing and the dust exposure (or concentration) identified in the risk management program. Other issues to be considered about the task include:

- worker activity
- does the worker need unrestricted mobility
- task duration
- vision and communication or is it an emergency situation
- whether there are other contaminants present.

In choosing the respirator with adequate performance, there are two parameters which have to be matched. These are the:

- required minimum protection factor (RMPF)
- class of respiratory protection.

Respirator filters for particles are graded in terms of their performance in removing particles from air to be inhaled. P1 filters have the lowest performance, and P3 filters the highest. Table 3 shows the different kinds of nominal protection factors provided by different combinations of face piece and filter. Table 4 provides some examples of how calculations of required minimum protection factors are made.

Protection factors

Table 3 shows examples of the protection factors of respirators for silica dusts.

Typical Protection Factor	Suitable respirator type for mechanically generated silica dusts	Typical group
Up to 10	Any of P1, P2 or P3 filters with half face piece, replaceable or disposable filter.	A
Up to 50	• P2 filter in full face piece • PAPR with – P2 filter, any head covering • PAPR with P3 , any head covering • Half face piece respirator with positive pressure demand or continuous flow airline.	B
Up to 100	• P3 filter in full face piece • Full face piece air hose type.	C
100+	• PAPR with P3 filter, head covering and blouse • Head covering airline respirator –continuous flow • Full face piece – continuous flow or +ve pressure demand air supply.	D

PAPR = Powered air purifying respirator

RMPF is determined by the combination of the measured dust concentration and the workplace exposure standard by the simple formula

$$\text{Required Minimum Protection Factor (RMPF)} = \frac{\text{Observed Dust Concentration}}{\text{Workplace Exposure Standard}}$$

Table 4 Examples in determining the level of respiratory protection needed.

Concentration of respirable crystalline silica mg/m^3	Workplace exposure standard mg/m^3	Required minimum protection factor	Minimum respirator group type
0.4	0.05	8	Group A
1.1	0.05	22	Group B
3.4	0.05	68	Group C
7.0	0.05	140	Group D

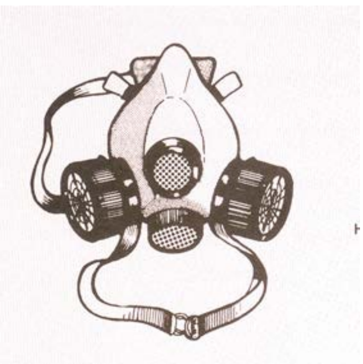
Use *Australian/New Zealand Standard 1715:2009 Selection, Use and Maintenance of Respiratory Protective Equipment* for more extensive guidance and more options on selecting respirators for the workplace.

Operator considerations are covered by three main issues. All workers needing to wear respiratory protection need to have their basic physiological conditions assessed. Workers with general breathing difficulties, asthma or heart conditions may be unsuited to the use of some types of respiratory protection. Users must have their facial fit test assessed to ensure that a respirator fits and does not leak during use. In addition, the wearer should make a fit check of the respirator each time it is used. User acceptance influences such issues as ensuring it is used all the time, does not impose unduly upon the comfort of the wearer and is culturally acceptable (e.g. for beard wearers).

Some different types of respirators for use with RCS are shown in Figure 16 *(Source: NOHSC).*

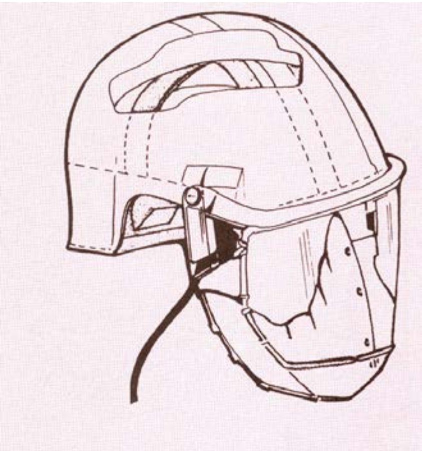
P1 disposable face piece respirator

P1/P2 disposable face piece respirator with exhalation valve



Half face piece respirator with disposable cartridge filters

Full face piece respirator with disposable cartridge filters



Powered air-purifying ventilated
Helmet respirator

Full face, positive pressure demand
(air-line supplied) respirator

Figure 16 Examples of respiratory protective equipment typical for use with RCS.

Step 5: Health monitoring for silica

Health monitoring for crystalline silica is applicable under Chapter 7.1, Division 6 of the WHS Regulation. Section 368 of the WHS Regulation expresses the duty for the PCBU to provide the health monitoring for RCS. Although crystalline silica is listed in Schedule 14 of the WHS Regulation, health monitoring is required only if a number of conditions are met. Monitoring may be required whether the silica comes to the workplace as a product with a label and an SDS or is generated in a process such as drilling, construction or tunnelling.

The principal condition requiring health monitoring is that the degree of risk is significant, i.e. *"if there is a significant risk to the worker's health because of exposure to a hazardous chemical"*.

The PCBU therefore needs to review worker RCS exposure data to determine if there is a significant risk to health. As a guide, regular ongoing unprotected exposure of workers >0.5 WES is considered a significant risk requiring health monitoring, as well as the need for control.

A subsidiary condition is that the work involving exposure to the silica is ongoing. Many job tasks involving silica, sand and cement will be trades with regular and ongoing exposure. For example, a worker involved in abrasive blasting, a moulder in a foundry, a mason or a paver cutting concrete blocks and tiles would all be involved in ongoing work with silica. An example of a situation where health monitoring is not required because the work has trivial silica exposure is a plumber or builder occasionally mixing cement.

Even if there are now adequate controls in place, but workers have previously been exposed for some time to an uncontrolled, significant risk from RCS, then health monitoring should be considered. To minimise the need for health monitoring, it is vital to pay attention to the controls in order to assure that the RCS exposures are able to be classed as not significant. In most cases this can be achieved, though not in all.

Sections 369 – 372 on duties relating to health monitoring

These sections are straightforward administrative duties for the PCBU relating to:

- informing workers about the need for health monitoring for silica
- ensuring that health monitoring for silica is provided
- engaging a registered medical practitioner to conduct the health monitoring
- paying for the health monitoring.

The PCBU must arrange for the health monitoring to be done by a registered medical practitioner with experience in health monitoring.

What will the health monitoring program have in it and who does it?

Section 370 of the WHS Regulation uses Schedule 14 to inform on these matters relating to health monitoring surveillance for RCS.

If the health monitoring has to be undertaken, the program will include:

- a chest x-ray
- a demographic, medical and occupational history
- exposure record review
- provide health advice
- standard respiratory function test, including for example, FEV1, FVC, and FEV1/FVC (Forced Expiratory Volume in 1 second, and Forced Vital Capacity) (See Figure 17)
- standard respiratory questionnaire.

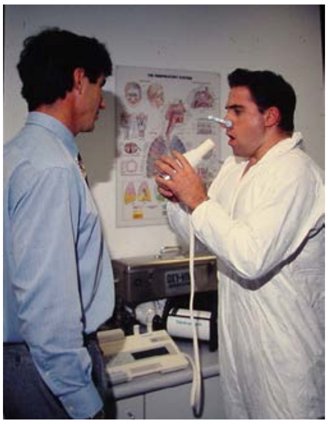


Figure 17 Worker about to blow into a spirometer for respiratory function testing

The medical practitioner and the health monitoring process

In addition to the duties for ensuring that health monitoring is carried out where required, the PCBU has other duties relating to this monitoring. WHS Regulation Sections 373 to 377 govern the health monitoring report and the actions the PCBU must follow regarding its disposition.

Section 373 identifies the information which must be provided to the registered medical practitioner regarding the worker. The relevant details are found on ***Form 28** Hazardous chemical health monitoring report* found at on the Workplace Health and Safety Queensland website.

Section 374 identifies the information that will be provided by the registered medical practitioner back to the PCBU in the form of the completed *Hazardous Chemical Health Monitoring Report*. This will include recommendations regarding the health management of the worker.

Sections 375 to 377 relate to the persons to whom the PCBU must provide the respirable silica health monitoring report. These are:

- the worker
- Workplace Health and Safety Queensland, but only if:
    - the report contains advice that the worker has a silica related disease or illness; or
    - the registered medical practitioner has made a recommendation for remedial measures to be taken in the workplace (e.g. improve ventilation, provide better respiratory protection), including whether the worker should continue in work exposed to the silica. It may contain information such as a recommendation that particular chronically over-exposed workers should refrain from further dust exposure
- any other PCBU who also employs the worker in work which involves silica exposure.

WHS Regulation section 378 and confidentiality of a worker's health monitoring report

The Health Monitoring Report is a document which is intended to assist in maintaining the health and safety of the worker in matters arising from worker RCS exposures. The PCBU has to have access to this document in order to assess the overall state of the operations about the impact of the

RCS on the health of the workers, and take guidance provided by the registered medical practitioner about improving the controls where indicated.

A health monitoring report may make a confidential medical record about the worker under the Report section 2 "Test or examination performed and results". This may include information pertaining to a worker's respiratory functioning, their X-Ray results, and other health matters (such as having asthma or other respiratory deficit) revealed by the tests or the questionnaire.

Section 378 restricts access to these confidential health monitoring reports unless the worker consents in writing to their disclosure, or unless the disclosure is to a person who must keep the record confidential under a duty of professional confidentiality (e.g. another medical practitioner).

Step 6: Keep records related to working with RCS

A workplace exposing workers to RCS will produce a number of documents which must be kept for significant time periods, and be available for inspection by various parties.

These records must be kept for a period of 30 years from the day a document was made:

- an air monitoring result (WHS Regulation Section 50). These records for respirable dust and silica must be readily accessible to those workers who have been exposed to the silica and
- a health monitoring report (WHS Regulation Section 378). The period here is for at least 30 years after the record is made, but it may be longer.

Workers who have been exposed at the workplace to the silica must be permitted ready access to their exposure records. A useful procedure for workers exiting a workplace where air monitoring and health monitoring have been carried out would be to provide those workers with copies of each relevant report pertaining to a worker. All air monitoring and health monitoring records may also be reviewed by a Workplace Health and Safety Queensland Inspector as part of an inspection process.

Step 7: Reviewing control measures for RCS

WHS Regulation Sections 38 and 352 contain new provisions relating to reviewing control measures for silica put in place by the PCBU. Reviewing control measures is a process which occurs only after all other duties e.g. control, air monitoring and health monitoring for silica, have initially all been addressed.

The situations which give rise to general duties are identified in WHS Regulation Section 38. These will include

- failure in the control process identified through excessive silica exposures
- change to processes - this might be a change of product or control processes, or working longer shifts in silica contaminated environments
- new RCS risks being identified – e.g. a change in an associated code of practice
- as agreed to by consultation between the PCBU and workers
- if a health and safety representative requests a review of the RCS controls.

Some specific situations for review of controls for hazardous chemicals are found in Section 352.

For RCS these include:

- changes in an SDS - a product composition change, variation in the WES for silica
- air monitoring results which are shown to exceed the 0.05 mg/m^3 WES for RCS
- a health monitoring report which indicates that a worker has a disease or illness (e.g. silicosis, emphysema) which is the result of RCS exposure
- any recommendation made by the registered medical practitioner to improve ventilation, upgrade respiratory protection or to remove a worker from further exposure to RCS.

In nearly all the above circumstances, the controls will be subject to both review and revision. Review of control measures is required at least once every five (5) years.

Step 8: Induction, information, training and supervision about working with silica

WHS Regulation Section 379 simply contains the skeleton process for induction, training and supervision which can be applied to all hazardous chemical use, including respirable crystalline silica. The induction and training which needs to be provided to workers about RCS will vary from one workplace to another, but the guidance below has been constructed by combining important material from the various key documents and on the job experience.

Induction, information and training programs for silica exposed workers will include topics on:

- Crystalline silica is known to be a substance hazardous to health and is subject to regulatory provisions.
- Information about silica can be found on the label of packed materials and in the SDS.
- Workers are to be trained about the use of the SDS, such as where to find it, and what its major features are:
    - identification of the hazardous chemical containing the crystalline silica, its product name, percentage composition and relevant physical and chemical properties
    - information on health effects caused by inhaling RCS
    - information on the workplace exposure standard for RCS
    - types of control available, including respiratory protective equipment.
- Risks to health arising from inhaling dusts containing RCS.
- Different health effects caused by RCS – silicosis, chronic bronchitis, emphysema, loss of respiratory volume, respiratory cancer and renal disease and independence of effects caused by smoking.
- Chronic nature of silica exposure and related diseases (latency) and why repeated short term exposures should not be tolerated.
- Specialised codes of practice such as the Foundry Code of Practice, the Abrasive Blasting Code of Practice, the Managing respirable crystalline silica in the stone benchtop industry Code of Practice and the Managing respirable dust hazards in coal-fired power stations Code of Practice according to nature of the workplace.
- How dusts containing RCS will be created in the individual workplace. This will include:
    - the materials being worked (e.g. cutting a concrete block)
    - materials being used which contain silica e.g. moulding sand, some polishing bars
    - processes used – cutting, grinding, polishing, moulding, pouring, fettling, blasting, and drilling.
- The purpose of control measures – intention to prevent or minimise dust exposure to workers (e.g. Table 1 can be useful).
- Any use of combined controls (e.g. ventilation and respiratory protection).
- How the control processes for RCS in each workplace are designed to operate:
    - How and when a ventilation system is to operate effectively
    - Details of damper operations (if relevant) of shared extraction systems
    - How the air flow into an extraction system can be checked, and how often it needs to be checked
    - Use of any administrative control systems operating in a workplace, e.g. limiting the time any worker is involved in work exposing them to RCS, preventing unprotected workers from entering into areas where RCS hazard is known to exist, signage and housekeeping
    - Using respiratory protection:
        - demonstrating why and how the correct particulate respirator has been selected for the task
        - ensuring that workers have had fit testing for their respiratory protection
        - ensuring workers are familiar with fit-check procedures each time they don their respirators
        - organising appropriate response for workers with medical problems associated with wearing respirators.
- Where respiratory protection is used, workers are familiar with maintenance procedures that have been set in place according to AS/NZS 1715, and need for cleanliness in storage.
- Importance of a maintenance system for respirators, the filter replacement schedules, and how to recognise respiratory exertion resulting from exhausted filter life.
- Recognition of importance of wearing respiratory protection for all, not just some, exposures.

- The purpose of any air monitoring procedures to determine the significance of risk from the RCS or to review controls.
- What the workplace exposure standard for RCS is, what the exposures in the workplace are, how they compare with the exposure standard, and actions taken to reduce overexposures.
- How an air monitoring program may be run, including wearing of personal dust monitoring equipment for respirable dust and RCS.
- When health monitoring for RCS has to be carried out in the workplace, the purpose of that health monitoring:
  - the consultation procedure necessary to choose a registered medical practitioner to carry out the health monitoring
  - what the individual components of that monitoring will be (respiratory function testing, questionnaire, occupational history, X-Ray if considered necessary.)
- Worker access to records on air monitoring for respirable dust and RCS and health monitoring.

The training may also advise the worker about maintaining individual copies of any individual dust exposures and health monitoring reports.

Workplaces should keep a record of training which identifies:

- who was trained and when
- who conducted the training
- details of the training such as those covered above.

Training is on-going and should be reviewed whenever a workplace identifies unacceptable changes in level of protection thought to arise from inadequate training retention, if new health information about RCS is received, or there are major changes in the way that RCS risks present in the workplace.

Are there any dangerous goods implications with silica?

No. Silicon dioxide is not listed in the Australian Dangerous Goods Code and so does not represent a dangerous good by virtue of either its physical or chemical nature (such as fire or explosion risk) in terms of either its transport or storage.

For more information

Visit Workplace Health and Safety www.worksafe.qld.gov.au or call the Infoline on 1300 362 128.

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