# GOOD PRACTICE TO CONTROL SILICA DUST EXPOSURE DURING NSW TUNNEL CONSTRUCTION

## *Air Quality Working Group*
## *Information Package - Part 2 of 12*

**December 2018**

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# 1 PURPOSE

The Australian Tunnelling Society (ATS) recognises the importance of health and safety in our industry in addition to valuing the strong experience and contribution of its members to support key stakeholders in our ever-growing sector. The ATS recognise that collaboration with industry stakeholders is essential to both raise awareness of the important issue of silica dust control, but also to enable effective strategies to be developed that will ultimately be practical and a positive step forward.

The Air Quality Working Group (AQWG) was formed in 2017 as a collaborative platform to enable industry to work together to develop and implement health strategies in conjunction with regulatory efforts to improve occupational health outcomes, with an initial focus on respirable crystalline silica ("silica dust").

The AQWG membership collectively produced reference material for purposes of communicating information that currently does not exist in the tunnel construction industry's body of knowledge. There are 12 parts to the information package, and each part must be considered in the context of the other. This document represents Part 2 of 12 total parts as listed in **Table 1**. Documented material is considered to benefit the wider tunnelling industry and therefore is freely available on the ATS website.

**Table 1 – Complete list of material produced by the AQWG**

| Part | Document Title | Document Reference |
|---|---|---|
| Part 1 | NSW Air Quality Working Group Background & Methodology – Silica Dust Exposure and the Tunnelling Industry | Doc No. AQWG_0_0.07 |
| Part 2 | Good Practice to Control Silica Dust Exposure During NSW Tunnel Construction | Doc No. AQWG_1_0.08 |
| Part 3 | Silica Dust Awareness Package | Doc No. AQWG_2_0.21 |
| Part 4 | Silica Dust Awareness Package Speakers Notes | Doc No. AQWG_2a_0.04 |
| Part 5 | Design and Procurement - Industry Considerations | Doc No. AQWG_3_0.09 |
| Part 6 | Scrubber System - Case Study | Doc No. AQWG_4_0.09 |
| Part 7 | Ventilation During Tunnel Construction - Industry Considerations | Doc No. AQWG_5_0.08 |
| Part 8 | Portal Misting System - Case Study | Doc No. AQWG_6_0.05 |
| Part 9 | Roadheader Cabin Air Filtration - Case Study | Doc No. AQWG_7_0.06 |
| Part 10 | Respiratory Protective Equipment - Industry Considerations | Doc No. AQWG_8_0.07 |
| Part 11 | Monitoring RCS Exposure - Industry Considerations | Doc No. AQWG_9_0.07 |
| Part 12 | Health Monitoring for NSW Tunnel Construction Workers – Industry Considerations | Doc No. AQWG_10_0.14 |

The information presented draws on the collective experience of those working across some of Australia's largest tunnelling projects. It was produced with the aim of creating information that captures a range of practices from differing subsurface operations from a broad spectrum of tunnelling conditions. In doing so it provides a point of reference to identify a range of practices to silica dust management. This includes providing information on a range of common control measures that may result in a reduction of silica dust exposure, and to provide general information to enable companies to improve dust control practices in the tunnel construction industry.

Silica dust exposure is a known health risk to humans. While this document identifies a range of strategies that can reduce worker exposure to silica dust, it does not consider the value in the individual measures listed herein to reduce exposures, and in turn, reduce illness and disease. This document is not intended to be as a standard or "de-facto" standard. Material provided in is for information only and Contractors would be expected to make independent enquiries as to the suitability of such information for their own use.

This document provides examples of measures which may be considered helpful for reducing silica dust exposure, and supports the existing Safe Work Australia Guide for Tunnelling Work.

## 2 SILICA DUST AWARENESS INFORMATION

Volunteers of the Air Quality Working Group have produced a ***Silica Dust Awareness Package (Part 3)*** along with ***Speakers Notes (Part 4)*** on the hazards associated with silica dust during tunnel construction. The awareness package was designed to be able to be delivered as part of a project induction or tool-box talk.

It is recommended that training and awareness programs on silica dust, including site inductions, be modified and upgraded to suit specific project conditions and form part of ongoing health and safety training programs.

## 3 HEALTH RISK ASSESSMENT AND CONTROL

Tunnel construction in Sydney, NSW presents unique challenges, given the high proportion of quartz that is contained in the host rock of Hawkesbury Sandstone, Shale and Mittagong Formation. A comprehensive risk assessment should be performed during pre-construction investigation of ground conditions, during design, and during construction. Notwithstanding the need for risk assessment, there are specific work activities that are known to generate significant quantities of silica dust which can result in exposures above the Workplace Exposure Standard.

**Table 2** was produced to provide a list of these work tasks along with control measures that can be employed to reduce exposures to silica dust for information purposes. **Table 2** should be consulted as part of the risk assessment process for consideration where these tasks may be relevant.

**Table 2 – Work activities that can present a high-risk of Silica Dust Exposure and associated Controls**

| High Risk Task | Activity & Source Description | Example Control Measures |
|---|---|---|
| Shaft Excavation | Shaft excavation involves vertical excavation using excavators fitted with hammers, dozers, and/or twin headers.<br>Shafts can provide limited room for a ventilation scrubber system, so forced air ventilation is typically used. Due to this, the ventilation system can push contaminated air, although diluted, into areas where other workers are located. | Forced air fans delivering clean air to the base of the shaft which direct air upwards.<br>Fixed misting systems to suppress “fine” dust leaving the shaft.<br>Enclosed and filtered heavy plant cabins on heavy plant operating in the shaft.<br>P2[1] respiratory protection used for workers on-foot in a shaft. |
| H-Section Construction | The start of the adit represents a key challenge due to limited space proofing.<br>Challenges relate to the amount of space available for ventilation during the commencement of mined tunnelling. | Surface mounted scrubber systems; venturi fans and brattice to direct air to the scrubber system.<br>Positive pressure filtered cabins fitted to roadheaders along with dust suppression fitted to the rear tail conveyor.<br>Fixed misting systems to suppress “fine” dust.<br>P2 respiratory protection for all workers. |
| Top Heading Construction | Significant challenges exist with large headings as multiple items of heavy plant are required to be located at the face. | Forced overlap ventilation system with scrubber system (35-50m$^3$)<br>Initial static scrubber, moving every 80m – 90m<br>Enclosed cabins on Mitsui and Sandvik roadheaders<br>Walking / mobile scrubbers being moved every few cuts of the face<br>Venturi fans used to better direct air towards scrubbers<br>P2 respiratory protection worn when in front of the scrubber |

[1] Any reference to RPE assumes that an RPE program as per AS1715 is in place which includes requirements for mandatory respirator fit testing program and a clean shaven policy.

| High Risk Task | Activity & Source Description | Example Control Measures |
|---|---|---|
| Wet Shotcreting | Shotcreting generates high amounts of dusts and silica, but when metal fibres are used in the shotcrete mix, they can cause issues with damaging scrubber filters and augers.<br>The scrubber ventilation system may be turned down for short periods of time to compensate, or screens may be used to drop out the fibres before they reach the scrubber. | Remote operated and electric powered shotcrete rig.<br>P2 respiratory protection worn by shotcrete workers. |
| Cross Passage Excavation | A forced overlap system is good for removing dust at the face, but is not useful for works occurring back from the heading.<br>While good equipment is available (e.g. Brokk), the challenge exists in equipment availability and draw on power requirements. | Stubbing in cross passage during construction of the top heading aids in air flow for the secondary system.<br>Installation of half face brattice connected to individual scrubber during XP excavation.<br>P2 respiratory protection worn during cross passage construction. |
| Benching / Profiling and other Back-End Works | This work activity is located back from the main forced overlap ventilation system.<br>Surface miners are used for benching to create the bottom heading.<br>Surface miners and profilers generate a significant amount of dust, even with dedicated ventilation systems.<br>A challenge exists with regards to sequencing and timing of the works so that the use of surface miners/profilers is restricted to when there are fewer workers in the area. | Where practicable, plan ahead and use machinery that can cut at a full-height to start with, thereby preventing the need to excavate the bench separately (e.g. Mitsui roadheader).<br>Consider surface miners which come with in-built dust scrubbers with a shroud over the head for dust extraction.<br>Consider Trencor Trenchers which utilise a tow-behind scrubber for dust control.<br>Install a ventilation circuit dedicated to benching which includes dedicated scrubber and brattice systems.<br>Hammer under pooled water (where available) or install sprayers on hammers (cone spray).<br>Install misting curtains to prevent the spread of dust.<br>Restrict personnel on foot in immediate vicinity (i.e. set up exclusion zones). Transiting through allowed only.<br>P2 respiratory protection for workers located in heavy plant.<br>P3 PAPR respiratory protection for profiling off-siders and workers on foot (Minimum Protection Factor of 50). |
| Changing filters / scrubbers | The setup of equipment typically relies on workers to manually remove dust-laden filters. | P3 PAPR (Minimum Protection Factor of 50) where they cannot be wet down. |

| High Risk Task | Activity & Source Description | Example Control Measures |
|---|---|---|
| Underground Heavy Plant Operations | Although windows and doors are kept shut, elevated exposures have been recorded for this work group due to the need of getting out of the cabin to check the level on the back tray.<br>Mud from work boots eventually dries out on the floor of the cabin, which can then be liberated when the air conditioning is turned on and the floor is disturbed.<br>Silica dust can be embedded in fabric seats which can then be liberated each time a worker sits down.<br>Mud on the steps can dry out and breathed in when the operator gets out of the cabin. As 3-point contact is needed to walk down stairs, the worker is therefore facing towards the stairs while walking down. | Where practicable, install cameras in the cabin to negate the need for Moxy operators to leave the cabin, thereby significantly lowering the exposure level to the operators.<br>Moxy's operated with doors and windows closed.<br>Cover fabric seats with vinyl seat covers, or install leather seats to prevent dust being trapped in fabric.<br>Plant cabins are required to be cleaned out each day using HEPA vacuums and/or wet methods.<br>Wash down the stairs each shift.<br>P2 respiratory protection when in and out of the cabin. |
| Roadheader operator Auxiliary activities | When inside the RH cabin, the operator has the benefit of a positive pressure air filtered cabin, however, the RH operator needs to perform a variety of activities outside the cabin, and it is these activities that contribute to the bulk of RCS exposure.<br>It is particularly challenging when the RH operator is located downwind side of mucking activities.<br>High exposure tasks include pick and cutterhead changes when the head is dry and moving vent cans (particularly if dust-laden). | Split headings - helps with extraction at the face by reducing the area and increasing the air velocity.<br>Forced overlap ventilation with walking scrubbers.<br>Clean cabins – using HEPA vacuum.<br>Pulling back the road header and restricting personnel access into areas where high exposure tasks are occurring.<br>Washing down picks prior to changing out.<br>Washing down vent cans prior to relocating.<br>P3 RPE during vent can handling, filter changes and pick / cutter head changes where they can't be wet down.<br>Mandating a RH cabin filter changeout schedule e.g. Changing RH filters every 2-weeks. Workers involved in the changeout activity wear P3 RPE.<br>Minimum mandatory P2 RPE in the underground environment. |

# 4 CONTROLLING SILICA DUST EXPOSURE

This section presents information on general control measures that have been used on projects to reduce exposures to silica dust. The control measures adopted on a specific project to manage silica dust will vary dependant on the nature of the environment, the task to be performed, and the method in which that task is performed. The ATS have developed numerous documents to assist persons responsible in controlling exposure to silica dusts as referenced in this section.

## 4.1. Tunnel Design and Procurement

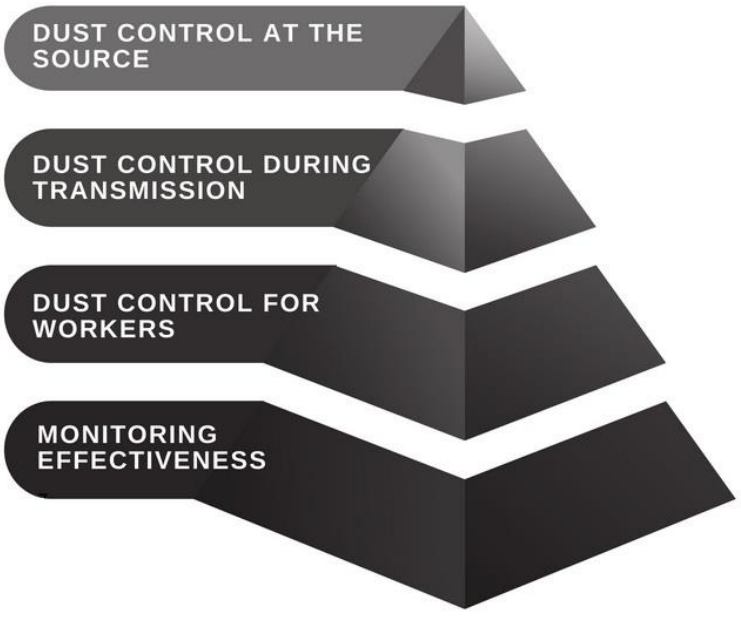
The most effective methods of controlling silica dust exposure are those that involve elimination, substitution and engineering controls, or those that are “higher up” in the control hierarchy. Decisions that enable or preclude the use of such “high-level” controls are made early in the project life-cycle however, and therefore, it is important to consider the risk and the need for control measures for silica dust at the time that Client organisations begin to develop and commission major projects.

***Design and Procurement Industry Considerations (Part 5)*** presents a series of key focus areas for Client organisations to consider, during project development, design, procurement, and construction phases to support the control of silica dust during tunnel construction. The key focus areas are:

1. *Select construction methodologies and processes*
2. *Encourage and enable innovative practices*
3. *Select minimum engineering techniques*
4. *Select minimum risk management processes*
5. *Select minimum tender scope.*

## 4.2. Controlling Silica Dust during Construction

Controlling the risk of silica dust exposure is managed through the hierarchy of control in the same way as other health and safety risks. Elimination of the hazard is the most effective means of control. However due to the nature of tunnel construction, it rarely presents a practical control measure in many cases. Notwithstanding, measures to eliminate or reduce the risk must be considered and be commensurate with the level of risk being addressed.




It is often found that the most effective way to reduce dust exposure is to implement control measures that reduce dust production at the source. In addition to source control, there are typically additional control measures implemented to control dust in the ambient environment “during transmission”. Lastly, additional measures are typically implemented to control dust

exposure to workers as a supplement to other control measures. A large part of controlling dust exposure is to monitor the effectiveness of the control measures in place, and to adjust or improve them, dependant on the results obtained. This includes the measurement of personal exposure to silica dust for example.

### 4.2.1. Dust Control at the Source

Effective ventilation extraction through the use of scrubbers, can remove significant quantities of silica dust generated through mined tunnelling, hammering, and excavation. The sizing of such scrubbers and the associated distance that the scrubber system can be placed from the source of dust generation, will vary greatly dependant on the tunnel system. Ventilation system design is a complex task, best performed by a dedicated Ventilation Engineer.

Notwithstanding its complexities, simple setup documents can be created to provide straight-forward processes for non-Ventilation Engineers to follow to inform persons responsible for relocating scrubber systems on their setup, limitations, information on for their relocation during excavation. ***Scrubber System Case Study (Part 6)*** produced by the AQWG provides such an example.

## 4.3. Dust Control during Transmission

### 4.3.1. Ventilation

Ventilation is also used to control ambient dust exposures. The AQWG have produced a document, ***Ventilation during Tunnel Construction (Part 7)*** which provides general information on ventilation used during tunnel construction to reduce exposure to silica dusts during mined tunnelling. It is targeted towards non-ventilation engineers for basic information.

It is important that any ventilation system is maintained and that preventative maintenance is regularly recorded. This includes daily inspections and verification checks. Regular and routine maintenance that is documented can assist in mitigating risk factors and identifying recurring areas of concern.

### 4.3.2. Misting Systems

In addition to ventilation, dust suppression can be used to control dust transmission. The ***Portal Misting System Case Study (Part 8)*** provides information on an air atomizing dust suppression system that has been shown in some circumstances to reduce the transfer of silica dust from portals to other adjacent operations.

## 4.4. Dust Control for Workers

### 4.4.1. Planning and Sequencing

Some activities, where not adequately planned, can detract from the efficiency of ventilation systems. By ensuring that high-dust generating activities such as hammering/mucking out, are only conducted in concert with ventilation system planning, exposures to workers can be minimised. Therefore, planning and sequencing with regards to dust control should be carefully planned and documented.

### 4.4.2. Filtered and Clean Cabins

The AQWG document ***Roadheader Cabin Air Filtration Case Study (Part 9)*** provides information on a roadheader cabin design that was used on a tunnel construction project to protect roadheader operators from exposure to silica dusts during mined tunnelling.

Heavy plant cabins can be a source of silica dust exposure. Mud from work boots can dry out on the floor of the cabin, which can then be liberated when the air conditioning is turned on and the floor is disturbed. In these situations, a period of each shift should be dedicated to cleaning the cabin to minimise deposited dust within cabins due to excessive entering and existing that increases the potential for secondary dust exposure.

### 4.4.3. Respite Stations

Workers are required to perform strenuous activities in underground environments that can be hot and humid. When combined with the requirements for high levels of personal protective equipment (PPE), including respiratory protection, this can lead to dehydration and/or the removal of PPE. Establishing dedicated “worker respite stations” where workers can cool down or have a drink can assist in managing risks of working in heat and potentially remove tendencies for removing protective equipment unnecessarily.

### 4.4.4. Respiratory Protection

In certain circumstances, respiratory protection will be needed for select work activities underground. Some of these activities result in exposures above 10 times the exposure standard for respirable crystalline silica such as excavation and hammering. These work activities should be identified prior to commencement, and workers provided higher levels of respiratory protection until higher order controls are implemented and shown to be effective.

Workers are not adequately protected from exposures to silica dust where respiratory protection is not fitted correctly. Training in the use, maintenance and limitation of the respiratory protection used, along with respirator fit testing complemented by a clean shaven policy should be conducted prior to use, where the respirator relies on facial fit to be effective. Fit testing records should be readily available for those that are required to use it.

***Respiratory Protective Equipment (Part 10)*** provides practical information on the use of Respiratory Protective Equipment where selected as a method to manage the risks associated with silica dust exposure during the construction of tunnels.

## 4.5. Monitoring Effectiveness

### 4.5.1. Exposure Monitoring

All aspects of health, safety, quality and environment systems are routinely audited to ensure they remain effective. The same processes should be adopted and applied to occupational hygiene, and, be conducted by a competent third-party person such as an occupational hygienist.

Exposure monitoring provides critical information regarding the extent of worker exposure and the associated risks, so that the PCBU can confirm if current control measures are sufficient to protect the health of the workforce and if additional control measures are necessary.

***Monitoring RCS Exposure (Part 11)*** provides practical information on methods that can be applied to monitor personal exposure of tunnel construction workers to respirable crystalline silica (RCS).

### 4.5.2. Health Monitoring

Some workers in the tunnelling industry are frequently exposed to silica dust and are required to utilise respiratory protection to control those exposures. Health monitoring for crystalline silica must be undertaken in accordance with the WHS Regulation (2017) even in situations where respiratory protection is used to control those exposures.

***Health Monitoring for NSW Construction Workers (Part 12)*** was produced with the aim of standardising processes and enabling consistency across the industry in how workers are selected to undertake health monitoring for crystalline silica.

# 5. Disclaimer

This good practice document has been developed by volunteers of the ATS Air Quality Working Group and draws on the collective experience of those working across some of Australia's largest tunnelling projects. The publication comprises 12 parts, and each part should be considered in the context of the other parts.

The information contained herein is for general information and educational purposes only; it is not a comprehensive list of all factors to be considered and is not a substitute for legal or technical advice.

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