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## Have you got your head in the sand? Respirable crystalline exposures of restorative stonemasons

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## Have you got your head in the sand? Respirable crystalline exposures of restorative stonemasons

### Abstract

Restoration stonemasons play a vital role in preserving culturally significant heritage buildings and the majority of culturally significant buildings in Sydney are constructed using Sydney sandstone, with an average silica content of 75%. Stonemasons conducting the close inspection required for precision sandstone grinding restoration works are considered at significant risk of exposure to respirable crystalline silica (RCS). An occupational hygiene survey was conducted to assess the risk of RCS exposure of restoration stonemasons conducting various tasks. Exposure monitoring for respirable dust (RD) and RCS was undertaken and the task of grinding sandstone determined as the highest exposure risk. 'Spinning' and 'Chopping out' tasks were identified as 'high risk' activities with excessive exposures of 4, 6 and 12 mg/m<sup>3</sup>, well above the workplace exposure standard (WES) of 0.1 mg/m<sup>3</sup>. Short duration task monitoring was conducted to better evaluate worker exposures and job rotation during the highest risk grinding task was not determined as a suitable control to reduce stonemason exposures. A trial was undertaken using on-tool dust collecting shrouds attached to local exhaust ventilation (LEV) system to evaluate the effectiveness and suitability to grinding tasks, with a 99% exposure reduction achieved. Reducing stonemason exposures below the WES was still not possible for grinding tasks; and numerous control measures were recommended to ensure workers are not exposed to concentrations of RCS likely to cause risk to health. Implementation of a combination of control measures is essential in reducing RCS exposure risk. Controls selected in line with the hierarchy of controls include:- mini enclosures, wet methods of dust suppression, on-tool dust collection shrouds and local exhaust ventilation (LEV); along with appropriate respiratory protection commensurate to exposure and powered air purifying respirators (PAPR) when grinding sandstone. Stonemasons grinding sandstone are considered at high risk of RCS exposure. They were encouraged to participate in equipment trials and evaluate their effectiveness. The more informed the stonemasons became, the more inspired they were to reduce their RCS exposure and integrate small, effective changes during sandstone restoration activities. Utilising knowledge from industry experts was invaluable in ensuring a successful trial, and gaining the confidence of the cohort. Throughout the risk assessment process, the stonemasons increased their knowledge and understanding of RCS.

### Keywords

stonemasons, restorative, exposures, crystalline, you, respirable, have, sand, head, your, got

### Disciplines

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# HAVE YOU GOT YOUR HEAD IN THE SAND?

## Respirable Crystalline Silica Exposures of Restoration Stonemasons

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Keywords: *silica exposure, respirable, crystalline, stonemasons, grinding, sandstone*

### ABSTRACT

Restoration stonemasons play a vital role in preserving culturally significant heritage buildings and the majority of culturally significant buildings in Sydney are constructed using Sydney sandstone, with an average silica content of 75%. Stonemasons conducting the close inspection required for precision sandstone grinding restoration works are considered at significant risk of exposure to respirable crystalline silica (RCS).

An occupational hygiene survey was conducted to assess the risk of RCS exposure of restoration stonemasons conducting various tasks. Exposure monitoring for respirable dust (RD) and RCS was undertaken and the task of grinding sandstone determined as the highest exposure risk. 'Spinning' and 'Chopping out' tasks were identified as 'high risk' activities with excessive exposures of 4, 6 and 12 mg/m<sup>3</sup>, well above the workplace exposure standard (WES) of 0.1 mg/m<sup>3</sup>.

Short duration task monitoring was conducted to better evaluate worker exposures and job rotation during the highest risk grinding task was not determined as a suitable control to reduce stonemason exposures. A trial was undertaken using on-tool dust collecting shrouds attached to local exhaust ventilation (LEV) system to evaluate the effectiveness and suitability to grinding tasks, with a 99% exposure reduction achieved.

Reducing stonemason exposures below the WES was still not possible for grinding tasks; and numerous control measures were recommended to ensure workers are not exposed to concentrations of RCS likely to cause risk to health. Implementation of a combination of control measures is essential in reducing RCS exposure risk. Controls selected in line with the hierarchy of controls include:- mini enclosures, wet methods of dust suppression, on-tool dust collection shrouds and local exhaust ventilation (LEV); along with appropriate respiratory protection commensurate to exposure and powered air purifying respirators (PAPR) when grinding sandstone.

Stonemasons grinding sandstone are considered at high risk of RCS exposure. They were encouraged to participate in equipment trials and evaluate their effectiveness. The more **informed** the stonemasons became, the more **inspired** they were to reduce their RCS exposure and **integrate** small, effective changes during sandstone restoration activities. Utilising knowledge from industry experts was **invaluable** in ensuring a successful trial, and gaining the confidence of the cohort. Throughout the risk assessment process, the stonemasons **increased** their knowledge and understanding of RCS.

## 1. INTRODUCTION & BACKGROUND

Silica is an extremely common mineral and tens of millions of workers worldwide are exposed to this substance on a daily basis, with many workers suffering diseases caused by respirable crystalline silica RCS. Known as alpha quartz or crystalline silica, it is found in most types of rock, soil, sand, clay and gravel (AIOH 2009). As a major component in building materials such as stone, tiles, concrete and bricks, it poses a risk to health for many workers in a broad range of occupations and industries conducting crushing, blasting, grinding and cutting activities.

Commonly referred to as '*silica*', a higher risk profile is specifically associated with the inhalation of **respirable** sized crystalline silica particles (generally <10 µm) to the lower regions of the lungs (AS2985-2009), leading to the fibrotic lung disease '*silicosis*'.

'Acute' and 'accelerated' forms of silicosis are an increasing concern as rapid death can occur within months and/or several years of exposure (Leung et al 2012), where workers are exposed to RCS concentrations ranging from 1.5 to above 10 mg/m<sup>3</sup> (NIOSH 2002). 'Chronic' silicosis often diagnosed after 10 and 30 years of RCS exposure.

RCS is classified as 'carcinogenic to humans Group 1' by the International Agency for Research on Cancer (IARC 1997), as a 'definite lung carcinogen' by the USA National Toxicology Program (NTP 2000), and is the second highest occupational carcinogen in Great Britain with exposure to RCS considered to become one of the main causes of occupational cancer in the future (HSE 2014). Whilst the carcinogenic status of RCS is widely recognised around the world, it is currently not listed as a carcinogen on the SafeWork Australia Hazardous Substances Information System (HSIS), even though it was identified in Australia as an occupational carcinogenic agent requiring priority preventative action in 2012 (Fernandez et al 2012).

The majority of culturally significant buildings in Sydney are constructed using Sydney sandstone, with an average silica content of 75%. Therefore Sydney sandstone constitutes a significant health risk for restoration stonemasons preserving heritage sandstone buildings, and occupational hygiene assessment for RCS was conducted.

## 2. SITE & PROCESS DESCRIPTION

The majority of heritage restoration works undertaken at the site are conducted in-situ on sandstone buildings by stonemasons, with work areas often located on elevated scaffold. Site operators use a variety of manual and power tools such as lump hammers, chisels, angle grinders, jackhammers and saws.

Various activities are conducted at this site including 'chopping out' old weathered and degraded stone with grinder and jack hammer, 'spinning' with grinders, drilling out and pinning sandstone, patching and re-pointing stone, dry sweeping, dry shovelling waste, manual carrying and disposal of waste into skip bins etc.



Figure 1: Lump hammer & chisel

Figure 2: 'Spinning' with angle grinder

Figure 3: 'Chopping out' with grinder

Source: K. Alamango 2015

Excessive sandstone dust and debris can often be present on work surfaces. Controls such as wet dust suppression methods are not utilised to reduce the generation of dust, and water sprays aren't suitable for use with grinders. Respiratory protection is usually the only control used to protect operators from RCS exposure, and may be worn when conducting highly dusty tasks, and not when adjacent to dusty processes.

## 3. MEASUREMENT STRATEGY

An occupational hygiene study was conducted to assess the risk of RCS exposure of a small cohort of 7 workers replacing weathered sandstone on buildings, with personal exposure monitoring for respirable dust (RD) and RCS undertaken.

SIMPEDS miniature size-selecting cyclones were operated at a flow-rate of 2.2 Litres/min, and calibrated pre and post sampling using a calibrated secondary flowmeter as per AS2985-2009. Personal samples were taken within the operator breathing zone to estimate worker exposure to respirable dust (RD) and RCS during a representative work period of (e.g. 8 hours).

When required, 2 hour and 15 minute short term samples were taken during highly dusty tasks. Samples were taken and analysed in accordance with AS 2985-2009 'Workplace Atmospheres - Method for Sampling and Gravimetric Determination of Respirable Dust' in conjunction with the 'Direct on filter method' of the National Health & Medical Research Council (NH&MRC) 'Methods for Measurement of Quartz in Respirable Airborne Dust by Infrared Spectroscopy and X-Ray Diffractometry', October 1984.

The samples were analysed by NATA accredited laboratory Pickford & Rhyder Consulting using gravimetric techniques and the airborne concentration of RD was calculated using the total volume of air passed through the filter as per (AS2985-2009). RCS analysis by Fourier Transform Infrared (FTIR) Spectroscopy was chosen as its sensitivity has been determined superior to X-ray Diffraction (XRD) with detection limits of as low as 1 to 3 micrograms reported (Ojima 2003).

Results were compared with the current SafeWork Australia Workplace Exposure Standards (WES) for respirable crystalline silica of 0.1 mg/m<sup>3</sup> 8 hour, time weighted average (TWA). To place restraint on exposure excursions significantly higher than the WES, results were also compared with the (NOHSC 2001) permissible variation guidelines, where short term (30 minute) exposures should not exceed 0.3 mg/m<sup>3</sup> and single short term (15 min) values should not exceed 0.5 mg/m<sup>3</sup>.

Safework Australia does not publish a WES for respirable dust; however results were compared with the (AIOH 2014) 'Dusts - Not Otherwise Specified' (DNOS) trigger value of 1 mg/m<sup>3</sup> (TWA), where trigger values are considered reasonable benchmarks for control implementation.

#### 4. MEASUREMENT RESULTS

The estimated RD and RCS results, for 18 personal samples as measured over three days at the site are summarised in RCS ascending exposure order as follows:-

<b>OPERATOR &amp; TASK (8 hour samples, unless task samples as indicated below)</b>	<b>Respirable Dust (AIOH DNOS trigger value 1 mg/m<sup>3</sup>)</b>	<b>Respirable Crystalline Silica WES 0.1 mg/m<sup>3</sup></b>
Site Manager, supervising works	0.03	0.010
Site Manager, supervising works	0.04	0.024
Labourer, dry sweeping & water washing	0.40	0.115
Labourer, clean-up & pointing and clean with water gurney	0.31	0.140
Stonemason, water gurney cleaning, colour match/stone patching	0.30	0.179
Stonemason, drilling out pins, prepping stone for patching	0.55	0.323
Stonemason grinding and core drilling	0.51	0.350
Stonemason Patching, hand chiselling, opening up joints with grinder for 12 mins (2 hours)	1.20	0.824
Stonemason Grinder 'spinning' with dust shroud (15 mins)	2.11	1.21
Stonemason, indenting stone dressing with grinder	7.06	4*
Stonemason, spinning with grinder, patching & re-tooling with chisels	6.77	4*
Stonemason, stone preparation grinding, hammer & chisel	1.56	6*
Stonemason Grinder 'chopping out' with dust shroud (15 mins)	8.60	6.45
Stonemason, 'chopping out' using grinder & jackhammer	20.5	12*
Stonemason, demolish stone/'chopping out' using grinder & demolition hammer for 40 mins (2 hours)	19.5	15*
Stonemason, Grinder 'spinning' no dust shroud (15 mins)	170	97*
Stonemason, Grinder 'chopping out' no dust shroud (15 mins)	629	472*

BELOW RCS WES & AIOH RD DNOS trigger value

ABOVE RCS WES & AIOH RD DNOS trigger value

RD: Detection Limit 0.01 mg

RCS: Detection Limit 0.005 mg

\*Result calculated using percentage of RCS in stonemason RD samples as quartz amount exceeded FTIR calibration range of 1.0 mg per filter

## 5. DISCUSSION

RCS results for all stonemasons exceeded the WES of  $0.1 \text{ mg/m}^3$ , with some exposures calculated at 40, 60 and 120 times above WES. These results highlight significant risk for workers. RD results for stonemasons conducting spinning and chopping out tasks ranged from 7 to 20 times above the DNOS trigger value of  $1 \text{ mg/m}^3$ .

Results for short duration (2 hour) samples for spinning and chopping out tasks were 8 and 150 times above the WES, and they well exceeded the permissible variation guideline of  $0.3 \text{ mg/m}^3$ . Based on these results, a common control strategy such as job rotation would not be suitable.

The use of half face negative pressure respirators was the predominant method of RCS control for workers, however many exposures far exceeded the protection factor achievable by the respirators of 'ten times' the WES. In addition, the majority of operators had beards and/or significant stubble growth, and would not be adequately protected against RCS exposure (AS/NZS 1712:2009). This type of respiratory protection is considered ineffective for workers with facial hair.

Water, whilst generally not used for dust suppression on this site, is highly desirable as a control method as it not only reduces the generation of airborne dust, but also rapidly ages RCS dust, thereby reducing its toxic effect on lung cells (AIOH 2009). Dust captured at the source is the preferred method of controlling dust as it reduces contamination of the work area and reduces exposures for operators and adjacent workers. Therefore, to assess the effectiveness and suitability as a control method, and to quantify potential RCS reductions, equipment trials were undertaken using on-tool dust collection shrouds and local exhaust ventilation (LEV) systems to capture and control dust.

## 6. EQUIPMENT TRIALS

Trials were carried out using on-tool dust shrouds and an LEV system provided by Makita Australia. The trials were conducted by on-site stonemasons with and without dust collecting shrouds to assess effectiveness. The stonemasons were initially sceptical speculating that the use of dust shrouds would make tasks more difficult and not provide any benefit. The assistance and knowledge from Makita, an industry expert, was invaluable in ensuring a successful trial. They were able to recommend new and innovative tools incorporating anti-vibration technology and dust collection shrouds for a variety of equipment and stonemason tasks. This strategy proved very successful, ultimately gaining the confidence of site personnel.

Results for short term (15 minute) samples for stonemasons conducting spinning and chopping out tasks without dust shrouds were extreme at  $97$  and  $472 \text{ mg/m}^3$ , and well exceeded the permissible variation guideline of  $0.5 \text{ mg/m}^3$ . Where worker RCS exposures are greater than  $1 \text{ mg/m}^3$  in an 8 hour work shift, there is greater risk of **acute silicosis** (HSE 2006), and immediate action should be taken to reduce the generation of dust.



Figure 4: 'Chopping out' no dust shroud, Figure 5: 'Chopping out' with dust shroud, Figure 6: 'Spinning' with shroud

Source K. Alamango 2015

The trials for spinning and chopping out tasks with dust shrouds were very successful in reducing RCS concentrations by a **notable 99%**. However, even with dust shrouds and LEV, RCS concentrations were still 12 and 64 times above the WES for these tasks. Therefore implementation of combination of engineering controls along with a fully comprehensive respiratory protection program in accordance with AS/NZS 1715 is essential to adequately protect workers.

## 7. RESPIRATORY PROTECTION

The current respirators do not provide sufficient protection for many site tasks, only providing protection for operators exposed to RCS concentrations of up to 10 times the WES, if worn correctly by clean shaven, fit tested operators. It is noted that most site operators had full beards or several days' stubble growth meaning this type of respirator would have limited effectiveness due to inadequate facial seal.

Respirators must be suitable for the level of risk associated with individual tasks, with a variety provided to suit all workers, face sizes and shapes, and selected for RCS use from Australian Standard:- 'AS/NZS 1715:2009:- Selection use and maintenance of respiratory protective devices' with fit testing, respirator use and training mandatory requirements.

Respirators supplied for use were half face negative pressure respirators with replaceable particulate cartridges, for which most operators had not been fit tested. For this workforce, a powered air purifying respirator (PAPR) with P2 filter (e.g. 3M Versaflo M-406 PAPR belt mounted air units) is suitable where high levels of particulate protection is required (e.g. over 10 times and less than 50 times the WES) i.e. for most spinning tasks, or when operators have facial hair growth such as beard, goatee or stubble.

PAPR's with P3 filters are suitable to protect operators from RCS exposures up to and exceeding 100 times the WES, i.e. during chopping out tasks. Whilst PAPR's are widely recognised as appropriate for abrasive blasting activities, stonemasons conducting grinding activities are often exposed to RCS concentrations far in excess of abrasive blasters (HSE 2012), making PAPR's highly suitable for stonemasons. A clean shaven policy may be considered for operators not required to use PAPR's.

## 8. LOCAL EXHAUST VENTILATION (LEV) SYSTEMS

LEV systems for use with on-tool dust collection shrouds should be chosen as per the AS/NZS 60335.2.69:2012 'Requirements for wet/dry vacuum cleaners', with systems used for 'mineral dust (containing quartz)' required to be 'at least Class M'. In this document, Class M (Medium hazard) systems are suitable for use with hazardous substances with a WES of  $\geq 0.1 \text{ mg/m}^3$  such as the Festool Australia CT361M. However, Class H (high hazard) systems are listed as 'suitable for use with carcinogenic dusts' with a WES of  $< 0.1 \text{ mg/m}^3$ .

The UK Health and Safety Executive (HSE 2012) recommend the use of a minimum Class M system with silica dusts, to better maintain flow rate for superior capture and control of dust. European and International standards (i.e. *EN 60335-2-69 and IEC 60335-2-69*), recognise RCS as a carcinogen with Class H systems recommended.

There is much confusion with the Class of LEV system that should be used with RCS, and for any system in use, education and training is necessary. Most Australian industry suppliers recommend Class L (low hazard) systems for use with RCS and not the minimum requirement Class M system. In addition, whilst the RCS WES of  $0.1 \text{ mg/m}^3$  is borderline for classification as per AS/NZS 60335.2.69:2012, as it is considered a carcinogenic dust by IARC only a Class H system should be chosen for use to ensure workers are adequately protected.

Simple, relevant and practical information should be created by Government legislators to provide guidance to Australian Small and Medium Enterprises (SME) and industry suppliers, to advise suitable LEV systems for the control of RCS.

## 9. RECOMMENDATIONS

Implementing a range of suitable control measures is required to reduce worker exposure and the generation of RCS dust in the workplace, including but not limited to:- use of mini enclosures for dust containment, on-tool dust shrouds, minimum Class M LEV systems, regular housekeeping, water for dust suppression, training, provision of clean laundered clothing.

Implementation of a fully comprehensive respirator program including:- fit testing, training and appropriate respiratory protection commensurate to RCS concentrations for different activities, including PAPR's for high risk operators.

Health monitoring including work and medical history, physical examination, chest X-ray and lung function tests along with workplace exposure monitoring are required for all workers exposed to RCS above 0.05 mg/m<sup>3</sup> as recommended by SafeWork Australia and the AIOH.

RCS is currently classified as a hazardous chemical by SafeWork Australia. The reclassification of RCS as an occupational carcinogen in Australia, in line with the IARC classification, is considered important to drive action towards ensuring the protection of workers who may be exposed to RCS.

As a priority, it is recommended a new RCS fact sheet is developed created by Government legislators to provide the latest RCS guidance information to small and medium enterprises (SME), equipment suppliers etc. Guidance material should include the IARC carcinogenic classification of RCS, requirements for worker health and workplace exposure monitoring, appropriate types of respiratory protection for worker tasks and exposure concentrations, and cost effective engineering controls including dust collection shrouds and at least the minimum Class M LEV systems for use with RCS.

The creation of industry networking groups is recommended to share knowledge, where SME occupational health personnel can connect with experts including occupational hygienists and equipment suppliers. Information such as exposure data and new generation equipment, would greatly assist stonemasons and SME's with the preparation of RCS risk assessments and minimisation of RCS exposures.

## 10. CONCLUSION

Sampling results indicate restoration stonemasons are exposed to excessive RCS concentrations of up to and at times in excess of 12 mg/m<sup>3</sup>, even with dust shrouds, and therefore may be susceptible to inflammatory lung responses and respiratory system diseases such as silicosis. There is also greater risk of **acute silicosis** when RCS exposures exceed 1 mg/m<sup>3</sup>.

Exposure monitoring and grinding trials confirmed it is not possible to reduce stonemason spinning and chopping out exposures to below the WES with dust shrouds, and implementation of a combination of engineering control measures, including PAPR's with P2 and P3 filters for some operators and tasks, is essential in reducing RCS risk.

Whilst initially resistant, this stonemason cohort became more engaged as they trialled new equipment and practices. They observed the great effect of **integrating** small changes such as regular housekeeping and hosing of work surfaces to improve their workplace and reduce potential exposures to RCS. The more **informed** the stonemasons became about RCS, the more **inspired** they were to reduce their RCS exposures.



Utilising knowledge from industry experts was *invaluable* in ensuring a successful trial, and gaining the confidence of site personnel. Throughout the RCS risk assessment process stonemasons *increased* their knowledge and understanding of this hazardous material.

## 11. LIMITATIONS

Whilst numerous chemical and physical hazards were recognised during the survey, this paper is limited to the assessment of RCS & RD exposures.

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