Findings report:

Phase one audits of engineered stone benchtop fabricators in South East Queensland

Executive Summary

Research in Australia and overseas has found that workers fabricating bench tops from engineered stone can be exposed to levels of respirable crystalline silica (RCS) which are hazardous to their health. Engineered stone bench tops can contain up to 95 per cent crystalline silica. Cutting, grinding, sanding and polishing these bench tops generates large amounts of respirable crystalline silica (RCS) putting workers' health at risk. Exposure to respirable-sized particles can lead to a range of respiratory diseases including silicosis, a serious and irreversible lung disease. Workers exposed to RCS are also at increased risk for chronic obstructive pulmonary disease (COPD), kidney disease and lung cancer.

Workplace Health and Safety Queensland (WHSQ) within the Office of Industrial Relations is undertaking a proactive, industry-wide audit of stone bench top fabricators in Queensland in response to findings of the 2017 Queensland Inquiry into the re-identification of Coal Workers' Pneumoconiosis, the August 2017 New South Wales Parliamentary First Review of the Dust Diseases Scheme and the concerns of medical experts relating to an increase in silicosis diagnoses among workers in the industry.

Phase 1 of the compliance audits involved comprehensive field based research at 10 pilot workplaces in South-east Queensland undertaken by or under the supervision of WHSQ's certified occupational hygienist. The purpose of the pilot audits was to:

- identify stone benchtop manufacturing processes that expose workers to respirable crystalline silica (e.g. workers performing shaping, saw operation, polishers)
- understand the types of controls used in the industry
- assess workers personal exposure to respirable crystalline silica with respect to the existing dust controls measures such as water suppression, local exhaust ventilation, slurry management
- assess and determine the effectiveness of risk control measures in place to manage respirable crystalline silica exposure of workers.

The audit process included an initial walk through survey to identify respirable crystalline silica generating processes, assessing the work processes which included collecting personal air-monitoring samples to quantify exposures (3 full days of sampling at each workplace to capture a representative number of workers – 30 days of sampling in total). Workers were grouped into similarly exposed groups (SEGs) and the results of the personal exposure monitoring were used to estimate exposures for each SEG, see Table 1 below, allowing them to be measured against the current Workplace Exposure Standard (WES) for RCS of 0.1mg/m^3.

SEG	Description	Estimated SEG exposure (mg/m³)*
Shapers	Workers cut holes in slabs for taps, sinks or stovetops and conducted joinery and associated edge grinding of stone predominantly using powered hand tools.	0.69
Saw Operators	Workers operated bridge saws or similar slab cutting equipment that used a cutting blade on stone.	0.06
Finishers	Workers conducted all fabrication tasks associated with finishing a bench-top after it had been cut by slab cutting equipment. This included both shaping and polishing processes predominantly using hand tools.	0.057
Computer Numerical Control (CNC) Router/Water Jet Operators	Workers operated CNC routers or other similar equipment that used a cutting tool on stone. This group included water jet operators.	0.056
Polishers	Workers bevelled edges and polished stone using powered hand tools.	0.05
Labourer/Supervisor	Workers that conducted support tasks including operating forklifts and general labouring or supervision.	0.045

The personal exposure monitoring results revealed that:

- 88% of samples collected contained RCS
- 9% of results and the similarly exposed group (SEG) for Shapers exceeded the workplace exposure standard (WES) for RCS (0.1 mg/m³).
- 35% of results and five out of the six SEGs exceeded 50% of the WES (0.05 mg/m³). It is standard occupational hygienist practice that 50% of the WES is set as the action level where controls need to be improved to reduce exposure.
- 70% of results and all SEGs exceeded 0.025 mg/m³). This is the Threshold Limit Value [1] at which nearly all workers may be repeatedly exposed, day after day, over a working lifetime, without adverse effects to their health. However above this level there is a significant risk to health and RPE and health monitoring is expected.
- Workers in the Shapers SEG who are generally required to use grinders are at highest risk of exposure, with an estimated exposure of approximately seven times the WES.
- These results indicate that in addition to an improvement in higher order controls, respiratory protective equipment (RPE) must be worn to manage residual exposure risks and health monitoring is required to detect changes in workers' health.

[1] American Conference of Governmental Industrial Hygienists 2018 Threshold Limit Value for respirable crystalline silica https://www.osha.gov/dsg/annotated-pels/tablez-1.html

The Phase 1 audits revealed widespread non-compliance with work health and safety laws within the industry and found that:

- Dry cutting, grinding or polishing exposed workers to excessive amounts of dust.
- Water suppression was being used as the primary dust control.
- The results of monitoring indicated that water suppression alone was not always sufficient to ensure the safety of workers, especially when using grinders to cut stone.
- Respiratory protective equipment was not used by workers when using water supressed tools.
- Housekeeping required improvement across all sites, as evidenced by a build-up of dust on floors, walls and other surfaces.
- Personal exposure monitoring was not previously conducted at any of the sites visited.
- Health monitoring was not conducted at any of the sites visited.

Phase 1 audits allowed WHSQ to identify effective dust controls and this evidence was used to develop a *Safety alert – Immediate action required to prevent exposure to silica for engineered stone benchtop workers* and the *Protecting workers from exposure to respirable crystalline silica – Guide to safe bench top fabrication and installation* industry guide which outline effective dust controls and other safety matters. The alert and guide provide clear and urgent advice on immediate actions to be take n in the workplace and legal requirements to be complied with to ensure worker safety.

Phase 2 of the compliance audits, led by 22 specially trained inspectors supported by OIR occupational hygienists commenced on 20 September with over 130 workplaces identified for audit by the end of 2018.

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1. Introduction

Workplace Health and Safety Queensland (WHSQ) within the Office of Industrial Relations is undertaking a proactive, industry-wide audit of stone bench top fabricators in Queensland in response to findings of the 2017 Queensland Inquiry into the re-identification of Coal Workers' Pneumoconiosis, the August 2017 New South Wales Parliamentary First Review of the Dust Diseases Scheme and the concerns of medical experts relating to an increase in silicosis diagnoses among workers in the industry.

Engineered and natural stone used for bench tops contains crystalline silica, also called quartz. Cutting, grinding and polishing natural or engineered stone generates respirable crystalline silica (RCS), which puts workers' health at risk. Engineered stone bench tops can have a very high crystalline silica content of up to 95%.

Phase 1 of the compliance audits involved comprehensive field based research at 10 pilot workplaces in South-east Queensland undertaken by or under the supervision of OIR's certified occupational hygienist. The audit process included an initial walk through survey to identify respirable crystalline silica generating processes, assessing the work processes which included collecting personal air-monitoring samples to quantify exposures (3 full days of sampling at each workplace to capture a representative number of workers – 30 days of sampling in total). The purpose of the pilot audits was to:

- identify stone benchtop manufacturing processes that expose workers to respirable crystalline silica (e.g. workers performing shaping, saw operation, polishers)
- understand the types of controls used in the industry
- assess workers personal exposure to respirable crystalline silica with respect to the existing dust controls measures such as water suppression, local exhaust ventilation, slurry management
- assess and determine the effectiveness of risk control measures in place to manage respirable crystalline silica exposure of workers.

During phase 1, WHSQ assessed each individual worker's exposure to respirable crystalline silica using personal exposure monitoring. To do this workers were assigned into similarly exposed groups (SEGs) based on the process or task they completed for the majority of their work day. There were six identified SEGs as follows: shapers, saw operators, finishers, CNC Router/Water Jet Operators, polishers and labourers/supervisors. The results of the personal exposure monitoring were used to estimate exposures for each SEG and this allowed them to be measured against the current Workplace Exposure Standard for respirable crystalline silica of 0.1mg/m3.

The collection of samples was carried out using standard occupational hygiene methodology and in accordance with the Australian Standard on respirable dust sampling (AS 2985: 2009 – Workplace atmospheres – Method for sampling and gravimetric determination of respirable dust). The overall sampling strategy (i.e. who was sampled, how many samples were collected and expected similar exposure groups (SEGs)) were designed to assist in establishing a reasonable belief about the risk to health of workers, gather evidence about the tasks and processes that generate RCS and understand industry controls being used.

The findings from phase 1 auditing (based on personal air monitoring results, observations during the walkthrough survey and general dust management principles) allowed WHSQ to identify effective dust controls which focus on:

- Capturing or suppressing dust at the source of generation.
- Using processes that generate less dust (e.g. CNC routers for sink or stovetop cut outs).
- Containing water mist or waste created from process water suppressed processes.
- Providing distance or physical barriers between workers and dust generating processes.
- Frequently cleaning surfaces to prevent the build-up of dust.

In addition, only certain types of respiratory protective equipment should be used to protect workers from residual exposure risks of respirable crystalline silica.

2. Background

Crystalline silica is a basic component of soil, sand, granite, and many other minerals. There are three forms of crystalline silica including quartz, cristobalite and tridymite. Quartz is the most common form of crystalline silica and is found in products such as concrete, mortar, brick, blocks, pavers, tiles, natural and composite stone benchtops. Quartz content in stone benchtops can vary widely depending on the type of stone. Engineered stone can contain up to 95% quartz whereas a natural stone such as granite contains approximately 35%.

Workers may be exposed to airborne RCS during stone benchtop manufacturing processes when cutting, grinding, sanding and polishing, and during the installation of the stone benchtops.

RCS is a significant health-hazard for workers. RCS is too small to be seen under normal lighting, the small particle size allows it to stay airborne for long periods of time and it is easily inhaled deep into the lungs where it can be deposited and lead to a range of respiratory diseases, including silicosis, chronic obstructive pulmonary disease and lung cancer.

Silicosis is a serious and irreversible lung disease that causes permanent disablement and early death, and it is made worse by smoking. It is commonly caused by exposure to RCS over many years, but extremely high short-term exposures, as may occur when working with engineered stone benchtops, can cause it to develop rapidly.

Engineered stone has been widely used in Australian kitchens and bathrooms for the last 15 years. There is only one known manufacturer of engineered stone in Australia based in Victoria. Engineered stone products are commonly manufactured in China, Spain and Israel.

Within Australia, smaller benchtop fabricators generally source their stone from numerous suppliers/wholesalers, however some larger fabricators import their stone directly. There are approximately 130 workplaces engaging in the fabrication of engineered stone products in Queensland, with almost 80% located in the southern region of the state.

Figure 1 (below) provides a general description of work flow in the stone-benchtop fabrication industry. Each workplace varied slightly depending on work organisation, staff and layout.

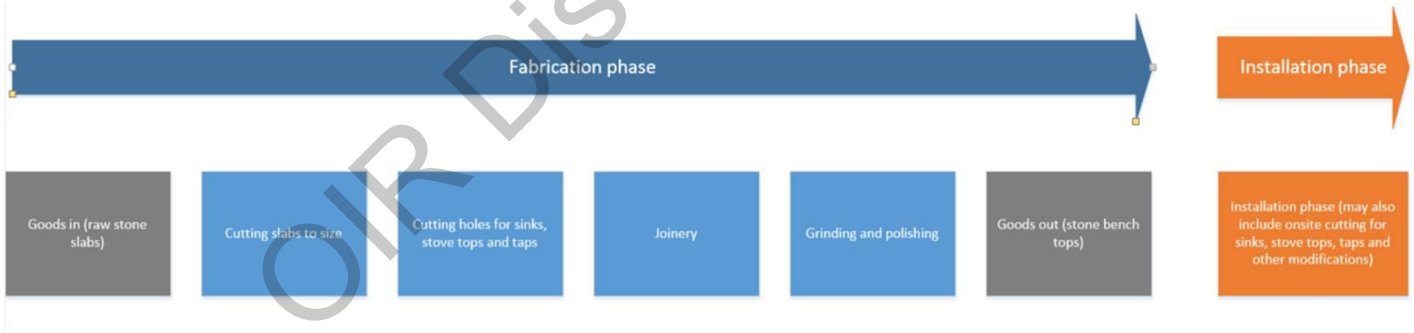

Figure 1 - Stone benchtop fabrication and installation process (general)

3. Management of risk

3.1 Workplace Exposure Standard (WES)

The current legislated workplace exposure standard (WES) for respirable crystalline silica in Australia is 0.1 mg/m^3 TWA [2]. Exposure standards do not identify a dividing line between a healthy or unhealthy working environment and are not considered as a strict acceptable level of exposure to workers. [3]

3.2 Action Level

Exposure standards for RCS are being reviewed and revised worldwide, including in Australia currently. [4] OSHA have recently reduced their permissible exposure limit to 0.05 mg/m^3 with an action level of 0.025 mg/m^3 for health monitoring. This is the Threshold Limit Value [5] at which nearly all workers may be repeatedly exposed, day after day, over a working lifetime, without adverse effects to their health. However above this level there is a significant risk to health and RPE and health monitoring is expected.

For this intervention, an action level of 50% of the exposure standard, that is 0.05 mg/m^3, was used for individual and similarly exposed group (SEG) results as a trigger to improve control measures in line with standard occupational hygienist practice.

3.3 Health risks

Under the *Work Health and Safety Regulation 2011*, PCBUs must ensure that risks from exposure are minimised as far as is reasonably practicable, not just until a statutory limit has been achieved. The enforcement procedure used by inspectors reflected this by focusing on control combinations known to reduce exposure to well below the current WES. This is because just complying with a statutory maximum does not mitigate health risks.

A recent OSHA literature review identified that the estimated risk of silicosis from 45 years exposure at 0.1 mg/m^3 (current WES) ranges from 60 to 773 cases per 1 000 and 0.05 mg/m^3 is between 20 and 170 cases per 1 000. At two and a half times the current exposure standard (0.25 mg/m^3) the risk of silicosis from 45 years of exposure is approaching 100%. [6]

4. Program Purpose

The purpose of the program was to:

- identify stone benchtop manufacturing processes that expose workers to RCS
- understand the types of controls used in the industry
- assess workers personal exposure to RCS and determine how effective current controls, specifically water suppression, are at managing dust risks.

[2] 8-hour Time-weighted Average (TWA) means the maximum average airborne concentration of a substance when calculated over an eight-hour working day, for a five-day working week.
[3] Safe Work Australia, 2013. *Guidance Note on the Interpretation of Workplace Exposure Standards for Airborne Contaminants*.
[4] Safe Work Australia. 2018. *Workplace exposure standards review methodology*. Retrieved from Safe Work Australia: https://www.safeworkaustralia.gov.au/workplace-exposure-standards-review-methodology
[5] American Conference of Governmental Industrial Hygienists 2018 Threshold Limit Value for respirable crystalline silica https://www.osha.gov/dsg/annotated-pels/tablez-1.html
[6] OSHA. (2016, March 25). Occupational Exposure to Respirable Crystalline Silica; Final Rule. *Federal Register Volume 81, Number 58*. United States of America: United States Departement of Labour, available at: https://www.gpo.gov/fdsys/pkg/FR-2016-03-25/pdf/2016-04800.pdf

5. Assessment process

Ten (10) sites were selected at random from a list of fabricators compiled through assistance of suppliers, WorkCover Queensland and internet searches. Engineered stone was the primary material used for benchtops at nine out of ten sites. Natural stone was the primary material used by Company 3.

Table 1 (below) provides a breakdown of businesses and workforce size.

Table 1 - Business name, location and approximate fabrication worker numbers.

Businesses	Number of fabrication workers
Company 1	<= 5
Company 2	6 to 10
Company 3	<=5
Company 4	>10
Company 5	6 to 10
Company 6	<= 5
Company 7	>10
Company 8	6 to 10
Company 9	6 to 10
Company 10	>10

The assessment process included an initial walk through survey to identify RCS-generating processes, assess the process which included collecting personal air-monitoring samples to quantify exposures.

The assessment only targeted fabrication of stone not the installation of stone. Installers made up a large portion of each businesses' workforce, however they were out of the scope of this intervention. Any feedback/comment from the PCBUs collected on this type of work was recorded.

The assessment of benchtop installers is expected to be targeted in future interventions.

5.1 Who was monitored

Similarly exposed groups (SEGs) were identified at each workplace during the walkthrough survey. Workers were assigned a SEG based on the process or task they completed for the majority of their work day (qualitative). Personal air samples were collected from workers in each of these groups. Table 2 below lists the groups and the tasks and description for each SEG.

Table 2 – Similarly exposed groups and process descriptions

SEG	Description
Saw Operators	Workers operated bridge saws or similar slab cutting equipment that used a cutting blade on stone.
CNC Router/Water Jet Operators	Workers operated CNC routers or other similar equipment that used a cutting tool on stone. This group included water jet operators.
Shapers	Workers cut holes in slabs for taps, sinks or stovetops and conducted joinery and associated edge grinding of stone predominantly using powered hand tools.
Polishers	Workers bevelled edges and polished stone using powered hand tools.
Finishers	Workers conducted all fabrication tasks associated with finishing a bench-top after it had been cut by slab cutting equipment. This included both shaping and polishing processes predominantly using hand tools.

SEG	Description
Labourer/Supervisor	Workers that conducted support tasks including operating forklifts and general labouring or supervision.

Air-monitoring was conducted over several days at each workplace to capture representative number of workers. Samples collected were analysed in an accredited laboratory[7] to determine RCS content. Personal exposure monitoring was used to measure workers' exposure to airborne concentrations of RCS (as respirable quartz and cristobalite). Refer to **Appendix A** for a detailed description of the methodologies used for personal exposure monitoring and analysis of results.

6. Results

6.1 Observations - wet processes

Figure 2 - Photo of a pneumatic polisher and grinder with water feeds.

Water suppression was the primary engineering control used to manage dust at all workplaces visited. Examples of water supressed equipment included water attached bridge saws, water-fed routers, waterjet cutting machines, water supressed polishing machines and water attached grinders and polishers.

Water feeds attached to machinery and hand tools supressed dust to the point where visible dust was not observable. As a consequence of applying water to rotating tools, RCS contaminated water mist was ejected from the process. This mist may have exposed workers by; drying in the air, being of respirable size and breathed in, or depositing on surfaces and later drying, only to becoming airborne again when disturbed.

Businesses assumed that where water suppression was used, RPE was unnecessary.

6.2 Observations - dry processes

Only one of the ten workplaces conducted dry cutting as a primary process. They complete sink and stovetop cut-outs, dry grinding, edge grinding and bevelling without water suppression or local exhaust ventilation. This was replaced with wet cutting and grinding methods after enforcement action. Five of the ten workplaces self-reported that they used dry cutting previously to fabricate benchtops.

None of the workplaces visited sanded or polished stone dry. Dry cutting, grinding and polishing is unnecessary and can be readily substituted for wet methods.

Figure 3 - Photo of two workers conducting dry cutting. Dust is visible on the floor and workers clothing. Enforcement action was taken to prohibit the process until exposure risks were managed. Photo by WHSQ.

This position is supported by the fact that all workplaces who self-reported previously using dry cutting were able to do the same tasks with wet methods.

[7] Laboratory analysis of personal air monitoring samples collected was conducted by TestSafe Australia

6.3 Observations - housekeeping practices

A slurry of stone and water was created by wet processes. All the sites visited had some form of curbing and channelling installed to contain and remove the slurry. In many cases slurry was allowed to dry on the floor and other surfaces leaving deposits of dry stone dust that could be disturbed and made airborne. The use of fans in the workplace for cooling or ventilation was likely to increase the rate in which wet surfaces dried.

It is likely that this poor housekeeping would increase the level of airborne RCS within the workplace and contribute to the exposure levels of all fabrication workers. Poor cleaning methods included the use of compressed air, dry sweeping or high pressure water. Poor cleaning may have generated airborne dust causing exposure.

Figure 4 - Instead of dry sweeping, squeegees were commonly used to move stone slurry into floor grates. Photo by WHSQ

Figure 5 - Photo of dust deposits allowed to dry. Fans may have assisted in drying wet surfaces leaving dry stone deposits.

6.4 Feedback regarding benchtop Installation

Installers, those workers that perform work off-site at customer/client locations, made up a large portion of each businesses' workforce, however their RCS exposure was not monitored during the project. One of the ten businesses subcontracted the installation of stone.

During the installation process, it was self-reported that alterations to slabs were sometimes required if they didn't fit and re-work/adjustment was required. Some businesses also conducted sink and stovetop cut outs on site.

Businesses reported that:

- alterations were rare
- grinders were provided to installers to use on site
- in some cases sink or stovetop cut outs were completed during installation
- these tasks were commonly conducted dry without any form of dust control.

Even a small amount of dry cutting or grinding can generate large amounts of dust putting these workers at risk. It is important to note that the work undertaken by installers would be classified as construction work.

A fact sheet has been developed on installing stone benchtops and it is likely that installers will be the focus of a third phase of audits in 2019.

7. Personal sampling

Table 3 below provides a breakdown of individual exposure measurements and estimated SEG exposures. Both sets of figures are expressed as 8-hour time-weighted averages (TWA). The geometric standard deviation (GSD) is a marker of variation of the data. For all SEGs the GSD was approximately between 2 and 2.5, this is common of workplace situations.

An action level of 50% of WES was used as an indicator of when controls improvement was required to manage exposure risks.

Table 3 - Summary of individual monitoring results (8-hour TWA) and SEG statistical analysis

SEG	Geometric standard deviation (GSD)	Range of exposures (mg/m^3)	Estimated SEG exposure (mg/m^3)*	Number of results that exceeded the action limit (50% of the WES)	Number of results that exceeded the WES
Shapers (n = 11)	2.21	0.069 – 1.03	0.69	11	10
Saw Operators (n = 55)	2.025	<LOQ – 0.142	0.060	23	2
Finishers (n = 47)	2.14	<LOQ – 0.110	0.057+	16	2
CNC Router/Water Jet Operators (n = 10)	2.35	<LOQ – 0.045	0.056+	0	0
Polishers (n = 25)	2.48	<LOQ – 0.097	0.050	5	0
Labourer/Supervisor (n = 13)	1.62	<LOQ – 0.058	0.045+	2	0
Workplace Exposure Standard (TWA)			**0.1mg/m³**		

*95% UCL

+approximation of the 95% UCL as the data was not lognormal

Note: the exposure results obtained may not be representative of the performance at all workplaces. This is due to variable factors such as different processes, tasks, tools, equipment, site layout and workload.

7.1 Shapers

- The individual airborne RCS levels measured for the Shapers (11 samples) ranged from a minimum of 0.069 mg/m^3 to a maximum of 1.03 mg/m^3
- The median individual RCS level measured was 0.21 mg/m^3
- The estimated SEG exposure was 0.69 mg/m^3, over six times the WES
- All results exceeded the action limit with ten results exceeding the WES.

7.2 Saw Operators

- The individual airborne RCS levels measured for the Saw Operators (55 samples) range from a minimum of less than the LOQ to a maximum of 0.142 mg/m^3
- The median individual RCS level measured is 0.045 mg/m^3
- The estimated SEG exposure is 0.060 mg/m^3 which exceeds the action level of 50% of the WES
- Of a total of 55 valid samples that were collected, 23 results exceed the action limit with two exceeding the WES.

7.3 Finishers

- The individual airborne RCS levels measured for the Finishers (47 samples) range from a minimum of less than the LOQ to a maximum of 0.110 mg/m^3

- The median individual RCS level measured is 0.037 mg/m^3
- The estimated SEG exposure is 0.057 mg/m^3 which is above the action level of 50% of the WES
- Of a total of 47 samples, 16 results exceed the action limit with two results exceeding the WES.

7.4 CNC Router/Water Jet Operators

- The individual airborne RCS levels measured for the CNC Router/Water Jet Operators (10 samples) range from a minimum of less than the limit of quantitation (LOQ) to a maximum of 0.045 mg/m^3
- The median individual RCS level measured is 0.022 mg/m^3
- The estimated SEG exposure is 0.056 mg/m^3 which exceeds the action level of 50% of the WES
- All of the ten samples were below the action limit and WES.

7.5 Polishers

- The individual airborne RCS levels measured for the Polishers (25 samples) range from a minimum of less than the LOQ to a maximum of 0.097 mg/m^3
- The median individual RCS level measured is 0.023 mg/m^3
- The approximate estimated SEG exposure is 0.050 mg/m^3 which is at the action level of 50% of the WES
- Of a total of 25 samples, five results exceed the action limit with no results exceeding the WES.

7.6 Labourer/Supervisor

- The individual airborne RCS levels measured for the Labourer/Supervisors (13 samples) range from a minimum less than the LOQ to a maximum of 0.058 mg/m^3
- The median individual RCS level measured is 0.032 mg/m^3
- The approximate estimated SEG exposure is 0.045 mg/m^3 which is just under the action level of 50% of the WES
- Of a total of 13 samples, two results exceed the action limit with no results exceeding the WES.

7.7 RCS exposures within each SEG

Figure 6 below shows a graph of the individual exposure measurements of each SEG.

- The green line indicates the 0.025 mg/m^3
- The orange line indicate the action level of 50% of the workplace exposure standard (0.05 mg/m^3) where control measures should be improved to reduce exposure.
- The red line indicates the current WES (0.1 mg/m^3)
- The plot for the Shapers SEG is an order of magnitude higher than every other SEG.

The graph identifies that approximately 70% of the exposures are above the green line (0.025 mg/m^3) at which RPE and health monitoring is expected.

Ten individual measured concentrations exceeded the WES for the Shapers SEG, compared with four for every other SEG combined (two in Finishing, two in Saw operators).

The majority of individual measured concentrations for the CNC Router/Water Jet operators, Labourer and Supervisor and Polishing SEGs are below the orange line (action level).

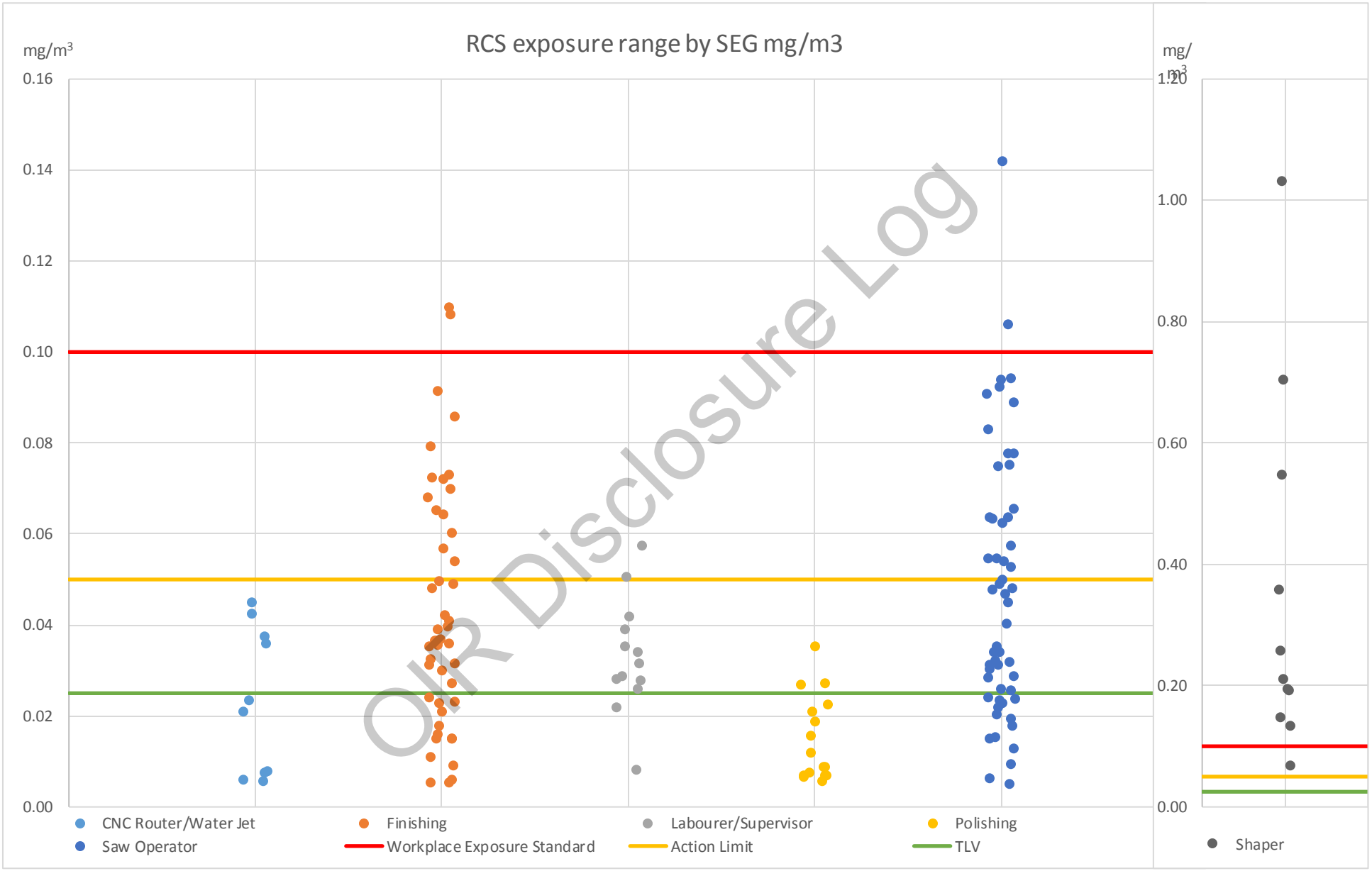

Figure 6 - Graph of individual exposures (8hr TWA) for each SEG

8. Discussion

It was found that 88% of all samples collected contained RCS. This is significant as water suppression was used in the majority of dust generating processes. Statistical analysis of the SEGs identified:

- All estimated SEG exposures exceeded 0.025 mg/m^3 (25% WES) the level at which RPE and health monitoring is required.
- Five SEGs equalled or exceeded the action level of 0.05 mg/m^3 (50% WES), the level at which controls require improvement.
- The Shapers SEG estimated exposure was approximately seven times the WES.

In regards to individual results:

- 70% of samples exceeded 0.025 mg/m^3
- 35% of samples exceeded 0.05 mg/m^3
- 9% of samples exceeded the WES (0.1 mg/m^3), a statutory maximum.

The results indicate that water suppression on its own it not 100% effective at preventing airborne RCS. This may be due to:

- Not all material being sufficiently wet when cut, ground or polished
- Contaminated water mist created by wet processes not being contained – as evidenced by dust settled on surfaces
- Speed of cutting equipment
- Design of equipment.

This is supported by other agencies findings regarding effectiveness of water. [8,9]

Monitoring results and process observations suggest that exposures can be affected by:

- Proximity to the tasks, i.e. the closer the worker is to the source of contamination/process, the more likely it is that contaminant can enter their breathing zone, however, workers exposed to purely background levels are still at risk (supervisors and labourers)
- Location of worker/task within area (ventilation)
- Individual worker techniques (e.g. placing a hand over grinder/polisher)
- Type of machine or hand tools used(bridge saw vs CNC router, grinder vs polisher)
- Speed of machine
- Design of machine (e.g. open guards vs closed on CNC).

In summary:

- Workers in the Shapers SEG are at highest risk of exposure
- Workers that use grinders are at higher risk than other workers
- An improvement of controls is required for SEGs exceeded 50% of the exposure standard
- All workers in the fabrication workshop require RPE to manage residual risks and health monitoring to detect changes in their health.

[8] Jared H. Cooper, D. L. (2014). Respirable Silica Dust Suppression During Artificial Stone Countertop Cutting. *Annals of Occupational Hygiene*, 122-126.

[9] National Institute for Occupational Safety and Health. (2016). *Evaluation of Crystalline Silica Exposure during Fabrication of Natural and Engineered Stone Countertops.* United States of America: Centers for Disease Control and Prevention.

8.1 Shapers

The shapers SEG was comprised of workers that undertook the joinery of stone and completed cut outs for sinks, taps or other holes using powered hand tools. Only two sites had shapers, Company 4 and Company 10. These workplaces allocated each worker a specific task rather than allocating a worker a specific benchtop to see through to completion.

The shapers SEG estimated exposure was 0.69 mg/m^3, approximately seven times the WES.

The majority of tasks completed required the use of water suppressed grinders to cut and grind stone. The use of grinders places workers at greater risk of exposure to RCS. [10] This may be due to:

- higher speeds of grinders drying water that has been applied
- an insufficient water supply or flow rate to supress dust
- water mist contaminated with RCS being ejected by the rotating blade.

While Company 4 primarily used wet work, the highest measured concentration for the SEG, 1.03 mg/m^3, was from a day the worker reported conducting small amounts of dry cutting and grinding during the shift. Engineering controls including mechanical ventilation were installed to prevent exposure however the personal exposure monitoring results indicate that it was not effective. RPE was not typically worn by workers at Company 4, regardless, exposures this high go beyond the protection afforded by half face air purifying respirators.

At Company 10 wet methods were used following a prohibition notice for uncontrolled dry cutting. Even with the use wet methods, all individual results for Shapers at this workplace returned measured concentrations above the WES. While the Shapers at Company 10 wore fit tested half face respirators to protect against exposure, further control was required to manage dust.

The use of grinders with cutting discs places workers a high exposure risks, even when water suppression is used. Alternative means exist to cut sink and stovetop cut outs, including CNC routers. If grinders are required to be used, they must be water suppressed and RPE worn to protect workers.

8.2 Saw operators

Saw operators used bridge or mitre saws to cut slabs to size. All saws observed were water suppressed, with water feeds directed at either the blade, slab, or both. The machines could either be manual or computer controlled.

The estimated SEG exposure was 0.060 mg/m^3, above half the WES, an action level for an improvement in control.

75% of individual measured concentration in this SEG exceeded 0.025 mg/m^3. This is despite the use of wet methods for cutting slabs.

Likely factors that contributed to the exposure levels recorded for these workers include:

[10] National Institute for Occupational Safety and Health, 2016. *Engineering Control of Silica Dust from Stone Countertop Fabrication and Installation,* Houston: s.n.

- the speed of operation, size and RPM of the blade
- the design of guarding and how well it contained water mist
- the operators positioning in relation to the process
- whether enough water was supplied for the saw speed both in terms of flow rate and volume.

Figure 7- Older manual bridge saws without any means to prevent workers from standing close to the process when operating the saw. Photo by WHSQ.

Figure 8 – Newer CNC bridge saws were fitted with bay doors. Photo by WHSQ.

8.3 Finishers

The finishers SEG comprised of workers that undertook any task required to finish a benchtop after it had been cut to size. Because work was organised by each benchtop rather each task, workers within this SEG rotated through the various stages of fabrication to see each slab to completion. They joined stone, shaped edges, cut sink, tap and stovetop holes and then polished stone using powered hand tools.

The estimated SEG exposure was 0.057 mg/m^3, is above half the exposure standard, an action level for improvement of control.

70% of the individual measured concentrations in this SEG exceeded 0.025 mg/m^3, despite the workers using water-attached tools.

Similar to the Shapers SEG, workers in this group also used grinders which placed these workers at higher risk of exposure. However, individual measures concentrations in this SEG were not as high as the Shapers SEG, likely due to task rotation.

8.4 CNC router/water jet operators

Routers and water jet machines are able to complete sink and stovetop cut outs. Some even leave an edge that does not require further polishing.

The estimated SEG exposure for this group was 0.056 mg/m^3.

Figure 6 shows that the all of individual measured concentrations are below the yellow line (action level) however the estimated SEG exposure is above the action level (0.05 mg/m^3). This is due to larger variation between worker results (GSD 2.35) and a small sample size (n = 10).

The results indicate that using a router or water jet machine to cut sink and stovetop cut outs results in far less exposure to workers. This is consistent with other jurisdictions findings when monitoring w orkers conducting grinding or cutting tasks vs using CNC routers. [11]

When comparing individual results between this SEG, the Finishing SEG and Shapers SEG:

- 40% of results exceeded 0.025 mg/m^3 for the CNC router/water jet operators SEG
- 70% of the results exceeded 0.025 mg/m^3 for the Finishing SEG
- 100% of results exceeded 0.025mg /m^3 for the Shapers SEG.

It is important to note that routers and water jet cutters cannot replace all tasks completed by the Shapers or Finishers, but rather they can be used re duce exposures of these SEGs. If sites had one of these machines, a recommendation was made to the workplace in their report to use them for sink, stovetop and tap holes rather than using grinders.

8.5 Polishers

The Polishers SEG comprised of workers that polished stone using hand-held polishers with resin discs as their primary task. The workplaces used water-attached hand-held polishers to prevent dust being released. Dry grinding or polishing was not undertaken.

The estimated exposure for a worker in this SEG was 0.050 mg/m^3, half the exposure standard.

Figure 6 shows that the majority of individual measured concentrations below the yellow line (action level) however the estimated SEG exposure is equal to the action level (0.05 mg/m^3). This due to larger variation between worker results (GSD 2.48) and a small sample size (n = 25).

48% of individual measured concentrations exceeded 0.025 mg/m^3 with the highest result, 0.097 mg/m^3, just below the WES.

Polishers applied water via a central feed, the rotation of the tool caused water to be sprayed outwards when operated. This meant that workers may have both been exposed from their own polishing and that of other workers in close proximity.

Containing the water spray created by the polisher is required to manage the exposure of these workers.

8.6 Labourer/Supervisor

Labourers and supervisors conducted support tasks that may have included supervision, cleaning, driving forklifts or general labouring.

The estimated SEG exposure was 0.045 mg/m^3, just under half the exposure standard. This is a concern because the workers of this SEG did not conduct fabrication related tasks. The exposure to these workers may be a reflection of the high background levels.

84% of individual measured concentrations exceeded 0.025 mg/m^3 with the highest result, 0.058 mg/m^3, exceeding half the WES.

[11] National Institute for Occupational Safety and Health. (2016). *Evaluation of Crystalline Silica Exposure during Fabrication of Natural and Engineered Stone Countertops.* United States of America: Centers for Disease Control and Prevention.

The exposures to this SEG could be a result of:

- dust generated from other processes or workers
- poor housekeeping (i.e. disturbing settled dust)
- using poor cleaning techniques that generated dust (high pressure water, compressed air, dry sweeping).

8.7 Respiratory protective equipment

Respiratory protective equipment (RPE) is a type of personal protective equipment (PPE) designed to protect the wearer from airborne contaminants. Respiratory protective equipment in the form of reusable or disposable, tight fitting half face respirators were commonly available for use at all workplaces visited but not worn by workers.

It was assumed by businesses owners and workers that respiratory protective equipment was not required for wet processes. Where dry processes were conducted RPE was commonly the only control to protect workers. In the instances where RPE was worn, the following problems were common:

- RPE was worn incorrectly
- RPE was worn by workers with facial hair or beards
- Workers were not fit-tested for the type and size of RPE provided
- Workers did not correctly clean, maintain or store reusable respirators.

Businesses owners and individual workers knowledge about fit testing and being clean shaven to maintain an effective seal was poor. Only one of the ten businesses visited had fit tested workers, and only due to previous enforcement action by an inspector.

Based on the results of the monitoring, RPE is needed to protect against exposure to RCS. For tight fitting air purifying respirators to be effective workers need to be fit tested to the type and size provided as well as be clean shaven.

8.8 Health monitoring

Health monitoring was not conducted at any of the sites, despite the fact that 70% of individual measured concentrations exceeded 0.025 mg/m^3. Feedback from businesses indicated the obligation to monitor workers health wasn't either known, considered or understood.

Recommendations were provided for nine of the ten workplaces to conduct health monitoring. Company 3 did not receive enforcement action to conduct health monitoring because individual and estimated average concentrations for RCS were below 0.025 mg/m^3

9. Enforcement action

After the walkthrough survey or as a result of personal air monitoring enforcement action was taken in the way of improvement and prohibition notices to ensure compliance with work health and safety legislation.

A total of 23 improvement notices were issued for inadequate dust control issues, use and fit testing of respiratory protective equipment and health monitoring.

A total of five prohibition notices were issued for dry cutting and other matters.

10. Recommendations

Communicate to industry effective controls to reduce or manage dust identified during the project.

Feedback from PCBUs indicated that there is limited knowledge about RCS risks and practical ways to manage those risks. In response to the outcomes of these phase one audits of stone bench top fabricators, WHSQ has taken immediate action to ensure employers comply with their health and safety duties and workers in the industry are protected:

- The Minister for Education and Minister for Industrial Relations, the Honourable Grace Grace MP, announced in Parliament and the media on 18 September 2018 that a safety alert and guide had been distributed to industry which included a prohibition on dry cutting of engineered stone benchtops.
- The industry safety alert *'Silicosis in stone bench top fabrication'* and guidance *'Protecting workers from exposure to respirable crystalline silica – guide to safe bench top fabrication and installation'* were distributed directly to the stone bench top industry and published on www.worksafe.qld.gov.au on 18 September 2018.
- Correspondence was also sent to approximately 360 entities identified through the Queensland Building and Construction Commission licence database.
- OIR has established an industry working group to support the development of a silica code of practice by early 2019. This will be followed by the development of an additional code on silica dust in the construction industry more broadly in early 2019.
- OIR is also undertaking ongoing work to develop a regulatory response to the risk posed by silica in the stone benchtop industry,

Expand WHSQ enforcement activities targeting RCS in the benchtop fabrication industry.

- All stone bench top fabricators in Queensland (approx. 130 businesses) are to be audited by the end of 2018. The compliance focus for the second stage has been built around minimising the risk to the health of workers through the assessment criteria outlined in the audit tool including:
    - Prohibition of dry cutting
    - Inadequate wet cut practices
    - Inadequate local exhaust ventilation practices
    - Worker isolation
    - Workplace ventilation
    - Housekeeping (ie limiting secondary exposure risks arising from poor housekeeping practices)
    - Health monitoring for workers exposed to RCS
    - Provision, maintenance and fit test of respiratory protective equipment
    - Information and consultation with workers regarding the risks of RCS

Appendix A - Air monitoring methodology

Respirable dust sampling and analysis was conducted in accordance with *Australian Standard AS2985 "Workplace Atmosphere – Method for Sampling and Gravimetric Determination of Respirable Dust".*

Personal sampling

Personal sampling was used to measure an individual's unprotected exposure to dust during the course of their usual work activities, and includes both exposed and non-exposed time (e.g. breaks).
Samples were collected from within each workers' breathing zone using a sampling pump attached to a SIMPEDS cyclone sampling head, containing a 25mm diameter polyvinyl chloride (PVC) (5µm) filter, via a flexible hose. The pump was operated at 2.2 litres/minute for a period of 4–8 hours on each worker. The flow rate of each pump was measured before and after a sample was collected. If the difference between the flow rates was more than 5%, the sample was deemed invalid. Sampling was carried out for the whole shift where possible, however a sampling time of less than a whole-shift was accepted provided it was more than 4 hours and representative of a worker's normal duties.
During personal monitoring, observations were made of the tasks undertaken as well as their frequency, duration, and the dust exposure controls in place to provide context to results. These observations are outlined in Table 3.

Sample analysis

Sample analysis of total respirable dust and quartz content was carried out by TestSafe Australia. The samples were weighed for total respirable dust using method number *WCA. 191 Gravimetric determination of respirable dust.* Samples were then analysed by X-Ray diffractometry (XRD) using *Method Number* WCA.220, *Determination of crystalline silica (alpha-quartz & cristobalite) in respirable dust*.

Results methodology

Individuals - exposure results that exceeded the action limit of 50% of the exposure standard are a trigger to review the existing exposure controls and to conduct health monitoring of workers. Individual results in excess of the workplace exposure standard (WES) for RCS require an immediate improvement in exposure controls (including respiratory protection).

Similarly exposed groups (SEGs)

The personal sampling results of individual workers within each SEG was combined in order to estimate the airborne concentration level that each group of workers was exposed to. The IHSTAT[12] program was used to carry out a statistical analysis of the combined results. The 95% upper confidence limit of the mean (average) of the groups' results (95% UCL)[13] was used to compare against the WES to determine risk to workers health.

[12] Mulhausen, J., 2007. *American Industrial Hygienists Association - IHSTAT+ v1.01.* [Online]
[13] 95% UCL is a number that one can be 95% confident that the true mean (average) concentration of the work group is below that value.

Where the 95% UCL exceeded the action limit of 50% of the exposure standard, a review the existing exposure controls and the provision of health monitoring for all workers in the SEG was triggered. An action limit of 50% of the workplace exposure standard is an important tool to protect the health of workers when used as limit for when action would be required to manage risk.

Where the 95% UCL result for the SEG was greater than the WES immediate improvement in exposure controls (including respiratory protection) was required.

Limit of quantitation

A limit of quantitation (LOQ) is the lowest level the laboratory analysis method was able to confidently detect and report on from a sample. The treatment of results that are less that the LOQ (<LOQ) is controversial and still an active field of research. For this assessment, where the laboratory reported results <LOQ for weight of RCS, these results were changed to 0.005mg, which is half the LOQ.

Limitations

The measurement results and conclusions presented in this report are limited by the methods of sample collection and analysis, and are representative only of the conditions and circumstances which were present at the time of sampling. Consequently, the results of this report should be considered to be, at best, an estimate of exposure (not absolutes) and not necessarily representative of all operating conditions or periods of time.

On 20 August 2018 SKC Limited announced the failure of an air sampling component to meet International respirable dust sampling standards. This component was used by WHSQ in carrying out the air sampling at your workplace. As a result of the failure, dust levels workplaces may in fact be up to 30% lower than those measured by WHSQ. WHSQ has written to the ten benchtop fabricators sampled in 2017-2018 to advise them of the fault and committed to re-sampling workers in early 2019. SKC Ltd's sampling cyclones have been removed from service and sampling cyclones have been purchased that meet international and Australian standards for respirable dust sampling.

Appendix B - Effective dust controls

Effective dust controls have been outlined below based on observations during the walkthrough survey and general dust management principles. Testing the effectiveness of the outlined controls could be an area for further work.

Generally, controls should focus on:

- Capturing or suppressing dust at the source of generation.
- Using processes that generate less dust (e.g. CNC routers for sink or stovetop cut outs).
- Containing water mist or waste created from process water suppressed processes.
- Providing distance or physical barriers between workers and dust generating processes.
- Frequently cleaning surfaces to prevent the build-up of dust.

In addition, RPE should also be used to protect workers from residual exposure risks of RCS.

Shapers/Finishers

Controls to prevent exposure for the shapers and finishers should focus on eliminating or substituting the use of grinders with cutting discs. This could be achieved by conducting cutting tasks on a router waterjet cutter or bridge saw.

Effective controls to minimise dust when grinders are used include:

- using water-attached or on tool extracted grinders
- applying a constant flow of water over the slab (sheet flow wetting) or wet the slab with water prior to cutting
- isolating the worker conducting the cutting from other workers using screens or physical barriers

Saw and CNC Router/Water jet operators

Effective controls for the Saw and CNC Router/Water Jet operators include:

- containing or capturing water mist using plastic shrouds, flaps or brush guards around the tool (refer to Figure 9 and 10)
- isolating the worker from the process either through physical barriers like bay doors or through distance
- maintaining water control systems to ensure an adequate flow of water during cutting
- preventing water drying on surfaces.

Figure 9 - CNC router without plastic shrouding to contain dust and water mist. Photo by WHSQ.

Figure 10 - CNC router with plastic shrouding. Photo by WHSQ.

Polishers

Effective controls to minimise exposure to the polishers include:

- using water-fed polishers to conduct all polishing and grinding work,
- containing or controlling water spray created by the polisher by retrofitting a brush guard or covering the spray using the operators hand
- isolating workers from other processes or workers by provided physical barriers such as screens between workstations
- local exhaust ventilation or natural ventilation to remove or dilute airborne dust
- preventing water drying on surfaces in the operators work zone
- wearing aprons and boots to prevent clothes becoming wet and dusty.

Supervisors/Labourers

Since the labour/supervisor SEG workers do not conduct any tasks that generate RCS, it is likely their exposures are the result of:

- RCS generating processes of other workers
- disturbance of dust due to poor housekeeping or cleaning methods.

Controls to minimise exposure should be focused on:

- Improving housekeeping by conducting regular cleaning with low pressure water or H class vacuum cleaners
- Controlling dust generated from the fabrication processes of other workers.

Respiratory protective equipment

Work health and safety legislation requires risks to be managed as far as is reasonably practicable following the hierarchy of control. RPE is a form of personal protective equipment, the lowest order of control in the hierarchy. Whilst effective at protecting workers from RCS, RPE does not reduce the level of RCS in the air. RPE is used to manage the remaining or residual risks following the implementation of other higher order controls, including water suppression or local exhaust ventilation.

The results of monitoring from all SEGs identified that workers need to wear respiratory protective equipment to manage exposure risks, regardless of the type of engineering control used.

A good respiratory protection program includes the following elements:

- correctly selecting appropriate RPE
- medical screening of RPE users
- training in the correct use and maintenance of RPE
- ensuring RPE is correctly used
- fit testing and fit checking
- inspection, maintenance and repair of RPE
- correct storage
- keeping records.