Respirable Crystalline Silica Exposures

in

Engineered Stone Benchtop Fabrication

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Executive Summary

Context and Approach

The objective of this study was to review, and report on, work practices and exposures to respirable crystalline silica (RCS) in a sample of South Australian workplaces fabricating engineered stone benchtops. In addition, SafeWork SA sought advice on potential control measures, and workplace perceptions of RCS hazard control and health monitoring.

The premises visited were five companies engaged in the fabrication of engineered stone benchtops. In addition, two contractors engaged in home installation were included in the study.

Work practices were studied, together with the various means used to reduce dust exposures. Dust exposures were measured for the various processes, and personal sampling of individual workers was undertaken to measure the time-weighted average (TWA) exposures to respirable crystalline silica (RCS) over the majority of a work shift. The latter were compared with the current Workplace Exposure Standard (8-hour TWA) of 0.1 mg/m^3 as respirable crystalline silica dust.

Findings

1. In many instances, dry processing (cutting, polishing and laminating) has been eliminated, as may be judged by observation and consultation with the workers and management. However, it was possible to observe and assess the level of dust generation from dry processing during home installation, <u>without</u> local exhaust ventilation (LEV). This showed that dry cutting can generate dust levels (and thus RCS exposure) well in excess of the current Australian Workplace Exposure standard for RCS. In addition, one instance of dry cutting was observed in a factory environment, <u>using</u> LEV. The exposure in this circumstance approached the exposure standard.
2. In the factory environment some excess TWA exposures to RCS were observed: In three instances the exposures exceed the Australian WES and in two other instances the "action level" of one-half of the WES was found. This was in spite of wet processes being used. The highest exposure level was recorded for a laminating activity.
3. A number of measures aiming to reduce exposures were observed. General exhaust ventilation was typically provided by either large exhaust fans in the roof/walls of the building or large bay doors at various locations throughout the buildings. Most of the work processes observed did not use local exhaust ventilation. Hand tool processes were generally done wet, either with water supplied to the tool or with the use of a hand water spray onto the stone prior to processing. Other measures included an exhaust booth, LEV with filter bag connected to a mitre saw wet cutting in combination with LEV, and a mitre saw connected with a dust collection bag.
4. Automated machine processing (CNC) was enclosed, and exposures were generally low in this situation.
5. Whilst respiratory protective equipment (RPE) was provided by employers, these devices were often poorly stored (and contaminated with dust inside) and were not used by all workers.

6 There was no evidence of health monitoring in any of the sites visited. The regulatory obligation to provide this to workers did not appear to be understood.

Recommendations

On the basis of observed work practices, consultation and measured exposures, the following recommendations are made.

1 **Dry processing should cease.** This is based on the observation of extremely high RCS levels, which cannot be completely controlled with LEV.

2 **Where dry processing cannot be avoided, such as in-home interior installation, wet spray in conjunction with tool-integrated LEV and RPE (positive pressure air purifying device) should be used.** PAPR provides a high level of protection and is suitable for persons with beards.

3 **Dusty processes should be isolated from general work areas.** This is to prevent unnecessary exposure to office staff and bystanders.

4 **Fabrication processes should be enclosed as much as practicable, consistent with good occupational hygiene practice.** Lower exposures were observed for enclosed machines.

5 **Effective wet methods for dust control must be used for cutting, grinding and polishing processes in a fixed fabrication facility.** While wet processes can be effective in reducing dust exposure, the effectiveness of this control may vary. A water spray prior to grinding or cutting of the stone may be limited in effectiveness compared with full water application on the tool during processing.

6 **Local exhaust ventilation should be utilised for processes in a fixed fabrication facility.** This will allow for the capture of dust at the source.

7 **A high level of housekeeping is needed, and wet cleaning methods or high efficiency particle filtration (HEPA) vacuum methods should be applied. Compressed air clean-up should not be used.** This is to prevent resuspension of settled dust.

8 **Where personal protection is provided in the form of a half face or full face dust mask (negative pressure air purify respirator), this should be individually fit tested, and training provided to the worker.** Simply providing respirators is not sufficient.

9 **Specific worker training should be provided.** The understanding of RCS exposure pathways and health implications (e.g. exposure from contaminated clothing), limitations of RPE (including the need for proper fit testing, storage and maintenance) should be included.

10 **Health monitoring should be provided.** All workers in the industry, other than office staff, should undergo health monitoring. This should also be available to workers with past exposure to dust but who have left the industry.

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1 Introduction

Engineered (artificial or composite) stone products (Caesarstone, Silestone, Romanstone etc) have become popular materials for benchtop fabrication. However, concerns have been raised about the potential health risks from dust exposure. Natural stone products, e.g. granite, may contain up to 40% crystalline silica; however the engineered products may have 90% or higher crystalline silica (mostly quartz) content by weight.

Recently published research raised the possibility of an elevated silicosis risk from work with engineered stone. The finding of a number of cases of silicosis, including accelerated silicosis, among Australian engineered stone benchtop workers, prompted the Thoracic Society of Australia and New Zealand (TSANZ) to raise the issue nationally.

Following discussions with SafeWork SA, Adelaide Exposure Science and Health (University of Adelaide) was commissioned to undertake a study of exposures to respirable crystalline silica (RCS) during the fabrication of engineered stone benchtops in South Australia.

2 Scope

The agreed scope of the work was:

1. Onsite monitoring of RCS for a representative sample of workers engaged in the production of engineered stone benchtops.
2. Investigation of the current work practices in fabrication benchtops.
3. Recommendations for the control of RCS exposure.

With respect to (1), it was agreed that this should be consistent with and build upon the sampling protocol for other jurisdictions. This comprised conventional monitoring of respirable dust/silica, but also added real-time monitoring of processes actively generating airborne dust and particle size distribution' for the purpose of assessment of dust and characterisation.

With regard to (2) and (3), a comprehensive report was to be provided to form the basis of future hazard control and health monitoring in the fabrication and installation of engineered stone benchtops.

The research team comprised Dr Sharyn Gaskin (Occupational Hygienist), Mr Ganyk Jankewicz (Occupational Hygienist) and Prof Dino Pisaniello (Occupational Hygienist) with specific expertise in hazard control and disease prevention, and with a track record in the international peer-reviewed literature, along with Dr Richie Gun (Occupational Physician), and Dr Hubertus Jersmann (Respiratory Physician and Secretary of the TSANZ). Shelley Rowett (SWSA) was also part of the project team, facilitating access to sites and providing project advice and support.

3 Information gathered from international evaluations

During a recent visit to US NIOSH (Morgantown, WV), researcher Dr Sharyn Gaskin obtained a report published by NIOSH characterising the USA exposure experience in this industry; a Health Hazard Evaluation Program Report by Zwack et al., (2016) titled *Evaluation of Crystalline Silica Exposure during Fabrication of Natural and Engineered Stone Countertops* (https://www.cdc.gov/niosh/hhe/reports/pdfs/2014-0215-3250.pdf). This report describes the evaluation of respirable crystalline silica exposure in a countertop manufacturing plant. It included monitoring of RCS in air, evaluation of ventilation systems, observation of work activities, production processes and personal protective equipment (PPE) use, interviews with employees about their work and health, and review of employees' previous spirometry testing results. They noted that there was no dry cutting in the facility.

Some of the RCS monitoring data presented in that report will be referred to in this report, for comparative purposes.

4 Description of workplaces visited and fabrication processes

A total of five workplaces fabricating engineered stone benchtops agreed to participate in the project, with an additional two installers included.

The fabrication workplaces visited were typically open sheds with designated travel paths (pedestrian and vehicle) and general machine or task locations throughout the area.

Work areas were open and ventilation was variable and could be influenced by weather conditions.

The **kitchen benchtop manufacturing process involved the following general steps**:

1. Template the benchtop – this involved making a template of the benchtop surface.
2. Use the template to develop a design file for the cutting and boring machines.
3. Cut as much of the benchtop as possible under wet machine conditions, this included some edge profiles that could be undertaken by wet machine edgers.
4. If the benchtop had joins and overhanging ("waterfall") edges – these were cut and glued, sometimes requiring hand held grinding after laminating.
5. Depending on the stone edge profile requested the benchtop was wet polished with handheld polishers in a finishing area.
6. The slabs were packed for installation.
7. At installation some sink void removals may require a dry hand cut at the installation site. These are kept to a minimum and respirators are provided.

5 Sampling strategy

All known benchtop fabricators were contacted by the research group and SWSA via email with a study information pack and invited to participate at a mutually convenient time to carry out dust monitoring. The criteria for carrying out the dust monitoring was that conditions would attempt to represent a worse-case scenario for potential dust exposure hopefully with high level of activity at the site.

The identification of similar exposure groups (SEG) was not straightforward. Some workers undertook a variety of tasks in a number of areas rather than having a static 'production line' working zone.

Workers were observed and classified according to tasks, as best as possible. Table 1 outlines the approximate SEGs classified for worker tasks.

Table 1: SEGs for monitored SA Engineered Stone Benchtop Fabricators

SEG #	SEG/task	Description
1	CNC Operator	Workers that operate CNC routers or similar equipment that use a cutting blade on stone.
2	Polishing/Edging	Workers that conduct tasks including bevelling edges and polishing of stone predominantly using hand tools.
3	Laminating	Workers that conduct joinery and associated edge grinding of stone predominantly using hand tools.
4	Foreman	Workers that conduct support tasks including general labouring or supervision.
5	Installer	Workers that conduct tasks including installation of engineered stone in commercial and/or domestic buildings, occasional use of hand tools.

6 Sampling Methodology

6.1 Respirable Dust and Quartz

Personal respirable dust samples were collected in the breathing zone of workers using SKC (Model 220-5000TC) personal air-sampling pumps set to a flow rate of 2.2 L/min and drawn through **Casella respirable dust cyclones** containing a pre-weighed PVC 25 mm (5 μm nominal pore size) filter. The flow rate was checked prior to and at the completion of the sampling period using a calibrated rotameter. The filter weights were determined gravimetrically for dust (CAHN 29 automatic electrobalance) and analysed for quartz by FTIR at MPL Laboratories. Replicate field and laboratory blank filters were recorded.

Two additional static samples from one site were collected in fixed positions along-side the direct reading instruments, to get an understanding of general background dust levels.

6.2 Direct reading instrumentation

A TSI® DustTrak™ DRX Aerosol Monitor (Model 8533, SN 8533165104, Calibration date 05/06/2018, Certificate No. DT210546) was used to simultaneously measure in real-time both mass (mg/m^3) and size fraction (PM_1, $PM_{2.5}$, Respirable, PM_{10} and Total PM size fractions). These were positioned statically in areas within the workplace where dust-generating processes were identified, and used during monitoring at installation of the benchtops off-site.

Two TSI® SidePak™ Personal Aerosol Monitors (Model AM520, SNs 5201648004 & 5201722002, Calibration dates 18/03/2018 & 18/04/2018, respectively) were also used fitted with the Dorr-Oliver Respirable Cyclone to differentiate the respirable fraction of the ambient aerosol; one was placed in a static fixed location and the other worn by the researcher on-site during the day of monitoring.

6.3 Assessment of particle size distribution

Sioutas four-stage cascade impactors were used for airborne dust sampling, which allowed for the separation of airborne particles by size. Each impactor consisted of three impaction stages, followed by a teflon after-filter. Particles were separated in the following aerodynamic particle cut point diameters: 2.5 µm, 1 µm, and 0.5 µm. Impactors were attached to a SKC Leland Legacy sampling pump operated at a flow rate of 9 L/min. The flow rates were checked prior to and at the completion of the sampling periods using a TSI 4100 Series High Performance Linear OEM Mass Flowmeter. Teflon (PTFE) filters (25 mm, 0.5 µm) were loaded in to each stage for particle collection, and 37 mm (2 µm) PTFE filter with support ring was used as the after-filter. Impactors were positioned for sampling in areas where workers spent time and were potentially exposed to dust containing quartz. At the end of sampling cascade impactors were dismantled and each stage filter weighed using a CAHN 29 automatic electrobalance, and dust concentration calculated. Each filter was photographed for records. Replicate field and laboratory blank filters were recorded for each size fraction.

7 Observations

For automated cutting and drilling tasks the workplaces sometimes used wet programmable equipment that freely drained into settling tanks from floor drains.

The amount of slurry splash was reduced in the workplace with fully vertically enclosed (walled) machines rather than those that were open to the walkways.

Dry cutting was not prevalent, but dry grinding was seen in two areas; respiratory protection was provided for this task – examples: after ‘laminating processes’ i.e. gluing edges onto the benchtop surface, edging in front of an exhaust booth.

Storage of, and understanding of the need for respiratory protection, varied.

7.1 Tasks in Engineered Stone Benchtop Fabrication

The main tasks the various workers carried out included Polishing/Edging, Laminating, CNC operation, and foreman/supervisor.

In general the Polishers spent most of their time wet polishing the edge profiles of benchtops. Similarly, a worker laminating would spend most of their day cutting edges for the benchtops using a drop saw, laminating the pieces on to the edge profile, and using some compressed air to ‘clean’ the dust from the surface after edging. The CNC operator tended to spend most of their time automating the process and ensuring wet process during cutting and boring.

The site Foreman/Supervisor tended to spend time at various locations and tasks, including moving benchtops between the various fabrication areas, and occasionally undertaking some grinding.

End-of-day clean-up practice typically consisted of wet sweeping methods. Generally poor housekeeping was noted for the majority of facilities.

The most common brand/type of engineered stone handled on the days of monitoring tended to be Caesarstone®, which represented the majority product used/purchased. An excerpt from the manufacturer’s SDS (overpage) shows that the crystalline silica composition is > 85%.

2. COMPOSITION/INFORMATION ON INGREDIENTS

Material	CAS Number	%
Crystalline Silica and other natural stone	14808-60-7	>85
Cristobalite	14464-46-1	<50
Polymeric resin		7-15
Additives		0-8

Some fabrication workplaces directly imported their own stone. SDS were not always available.

7.2 Dust control measures and other information

Little mechanical heating or cooling was noted on the main production floor of sites visited. General exhaust ventilation was typically provided by either large exhaust fans in the roof/walls of the building or large bay doors at various locations throughout the buildings. Most of the work processes observed did not use local exhaust ventilation. Hand tool processes were generally done wet, either with water supplied to the tool or with the use of a hand water spray onto the stone prior to processing.

One fabrication plant did have a large exhaust extraction system which was connected to a large exhaust booth used for edging and a mitre saw (together with water provision). These appeared to be reasonably effective although operator positioning was important. Another plant had LEV with filter bag connected to a mitre saw and a third plant used wet cutting in combination with LEV. Another plant had a mitre saw connected with a dust collection bag and was said to be usually connected up to a vacuum cleaner.

Employees in production areas were typically provided respiratory protective equipment (RPE) (examples included half-face Scott Safety Pro^2 P3, Sundstrom SR221 SR510P3 SR100), however these were not adequately stored nor used by all workers observed. Education in the limitations of RPE and the risks associated with RCS exposure appeared not well understood. In most instances, workers observed were not clean shaven. Uniforms/clothing were generally laundered by the employees.

Only one site had previously undertaken dust exposure monitoring. No medical surveillance program was in evidence for any of the sites visited. Health Monitoring is suggested in national guidance where exposures are not known and the substances have significant health effects or are not well controlled. The regulatory obligation to provide this to workers was not understood. Again, this may be due to the belief that wet methods are sufficiently effective.

8 Results and analysis of individual risk factors

The key results encompass job categories (SEGs) and tasks according to (i) respirable dust, (ii) quartz, (iii) dust particle size distribution, expressed as mass median aerodynamic diameter[1], and (iv) real-time dust monitoring.

The daily work hours were typically 8 hours (e.g. 0730-1530).

[1] Mass Median Aerodynamic Diameter (MMAD)
The "aerodynamic" diameter is used to compare particles of different sizes, shapes and densities and, in conjunction with other data, to predict where in the respiratory tract such particles may be deposited. Given that a broad range of size, shape and mass characteristics of particles dominate in the occupational setting, the Mass Median Aerodynamic Diameter (MMAD) is calculated to describe the average size distribution of airborne particles. As such, the MMAD is a statistically derived figure for a particle sample: for instance, an MMAD of 5 µm means that 50% of the total sample mass will be present in particles having aerodynamic diameters less than 5 µm, and that 50% of the total sample mass will be present in particles having an aerodynamic diameter larger than 5 µm.

8.1 Respirable dust

Table 2 shows **respirable dust** concentrations for personal and static monitoring. Mean (range). For comparison, example results reported by NIOSH for similar SEGs in the USA industry are also provided (Source: Zwack et al. 2016).

SEG/Task	Respirable dust (mg/m^3)	
	Current study	USA study#
CNC operator	0.08 (0.06-0.11) Wet, enclosed process	0.06
Polishing/Edging	0.17 (0.08-0.28) Wet and dry processes	0.08##
Laminating/cut-outs	0.55 Dry process	0.10##
Foreman/Supervisor	0.12 (0.07-0.17)	n/a
Installation	0.07 (0.06-0.08)	n/a
Static/positional Polishing/Edging	0.02 Wet process	n/a
Static/positional Laminating	0.22 Dry process	n/a
Background, in office adjacent to work area	0.05	n/a

geometric mean reported
wet process in USA, compared with both wet and dry cutting observed in the current study
n/a data not available

8.2 RCS/Quartz concentrations

Data collected on quartz concentrations recorded for each SEG/Task was obtained. Table 3 and Figure 1 show overall outcomes of quartz concentrations for each task/SEG group compared with the current SWA workplace exposure standard.

Table 3 shows **respirable crystalline silica** concentrations for personal and static monitoring. Mean (range). For comparison, example results reported by NIOSH for similar SEGs in the USA industry are also provided (Source: Zwack et al. 2016).

SEG/Task	**Respirable crystalline silica (mg/m^3)**	
	Current study	USA study#
CNC operator	0.03 (0.02-0.04) Wet, enclosed process	0.01
Polishing/Edging	0.07 (0.02-0.13) Wet and dry processes	0.07
Laminating/cut-outs	0.16 Dry process	0.03##
Foreman/Supervisor	0.03 (0.03-0.04)	n/a
Installation	0.01 (all samples 0.01)	n/a
Static/positional Polishing/Edging	0.01	n/a
Static/positional Laminating	0.09	n/a
Background, in office adjacent to work area	0.02	n/a

geometric mean reported
wet process in USA; compared with both wet and dry cutting observed in the current study
n/a data not available

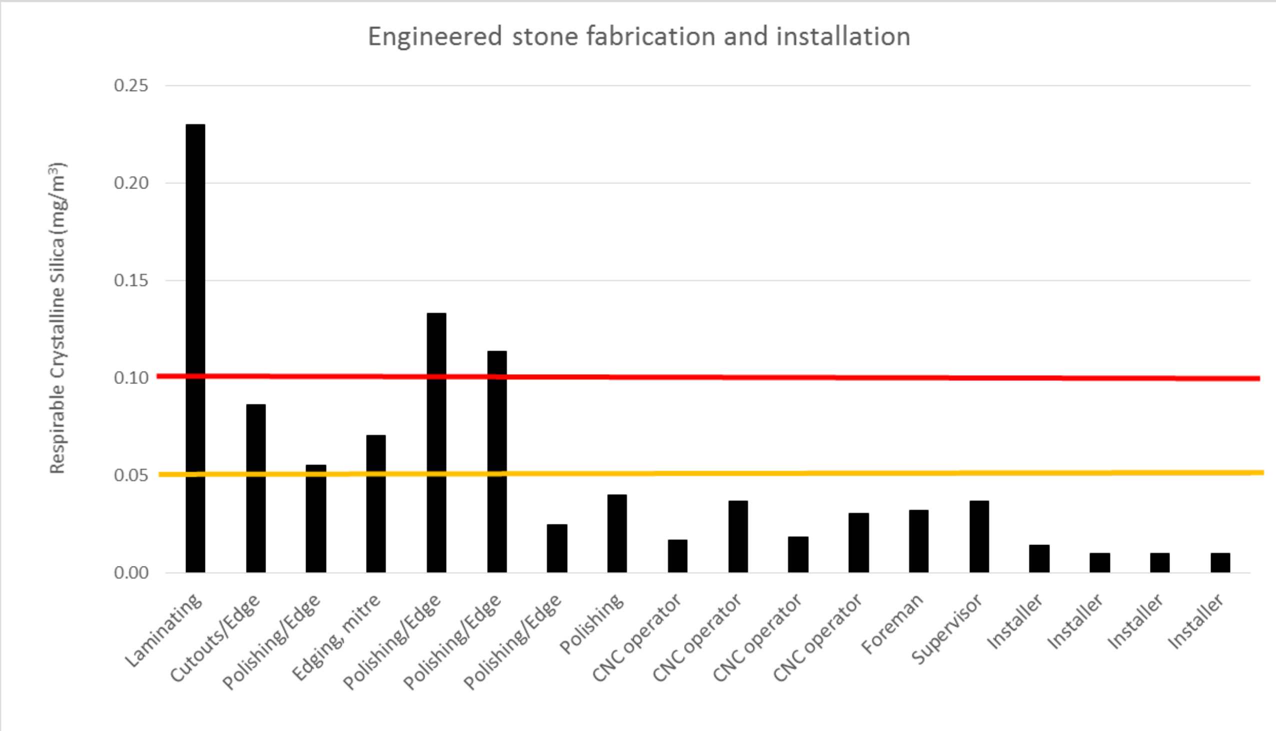

Figure 1: Quartz concentration (mg/m^3) for workers in each Task group/Similar Exposure Group (SEG). Red line represents the SWA 8 h TWA workplace exposure standard, and yellow line represents 50% of the workplace exposure standard.

8.3 Particle size distribution

Cascade impactor dust data obtained from two fabrication sites, yielded a total of three samples. The results for calculated dust mass median aerodynamic diameter (MMAD) are presented in Table 4.

Table 4: Mass median aerodynamic diameter (MMAD) of positional dust samples (n = 3) collected at two sites.

Sample location	**Total dust concentration (all stages) (mg/m^3)**	**Estimated 50% of size distribution (µm)**
Adjacent to Polishing Area (site 1)	0.08	**2.05**
Adjacent to Polishing Area (site 2)	0.32	**2.79**
Adjacent to Laminating Area (site 1)	0.23	> **2.5***

* required extrapolation to quantitate

An example of typical results of filters from each size fraction in cascade impactor stages is shown in Figure 2.

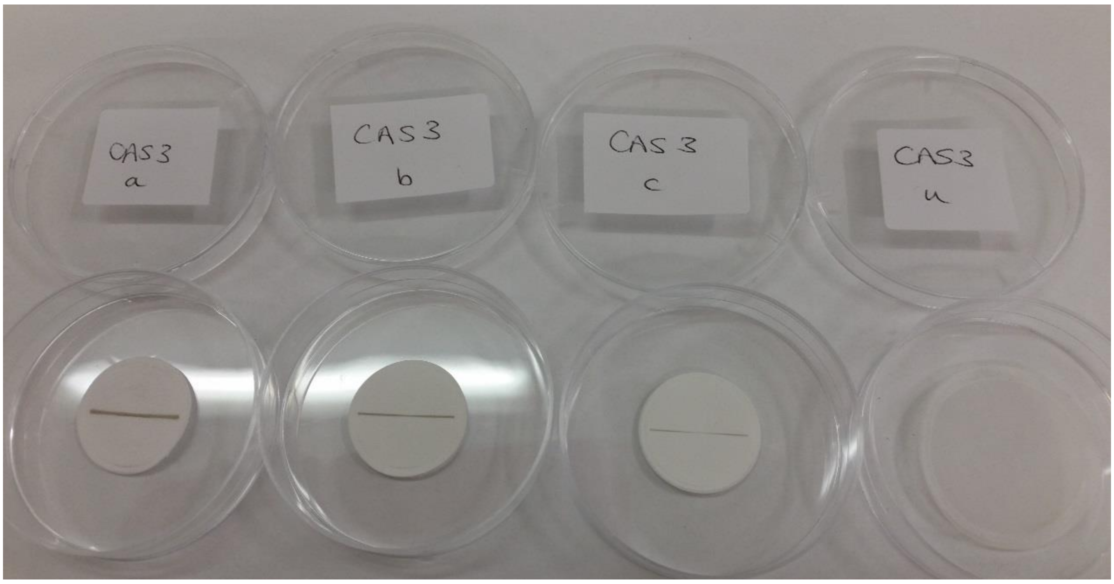

Figure 2: Typical examples of filters from cascade impactors: Stages 1-3 (25mm, left to right) and backup after-filter (37mm, far right), cut-off ranges 2µm, 1µm, 0.5µm, after-filter, respectively.

8.4 Real-time dust monitoring

The TSI® DustTrak™ DRX Aerosol Monitor was positioned (fixed) adjacent to the dust-generating process of Laminating (in this case a DRY process) at one fabrication site, and also used during installation for instantaneous dust measurement. It simultaneously measured in real-time both mass (mg/m^3) and size fraction (PM $_1$, PM $_{2.5}$, PM $_4$ (respirable), PM $_{10}$ and Total PM size fractions). Results for PM $_{2.5}$ size fraction, for example during fabrication (laminating area), are shown in Figure 3. Table 5 summarises the corresponding real-time dust measurements for each size fraction.

Table 5: Summary of real-time dust concentrations by size fraction, recorded from a fixed location during fabrication using **dry** processes (adjacent to Laminating area). Sampling length = 5hr 31min. Note: a fan and open roller door attempted for control of dust in general area, and filtering respirator protection for worker.

	Average (mg/m^3)	**Minimum (mg/m^3)**	**Maximum (mg/m^3)**
Total PM	2.06	0.02	109
PM_{10}	1.32	0.02	90.8
PM_4	0.82	0.01	65.7
$PM_{2.5}$	0.78	0.01	64.1
PM_1	0.76	0.01	63.7

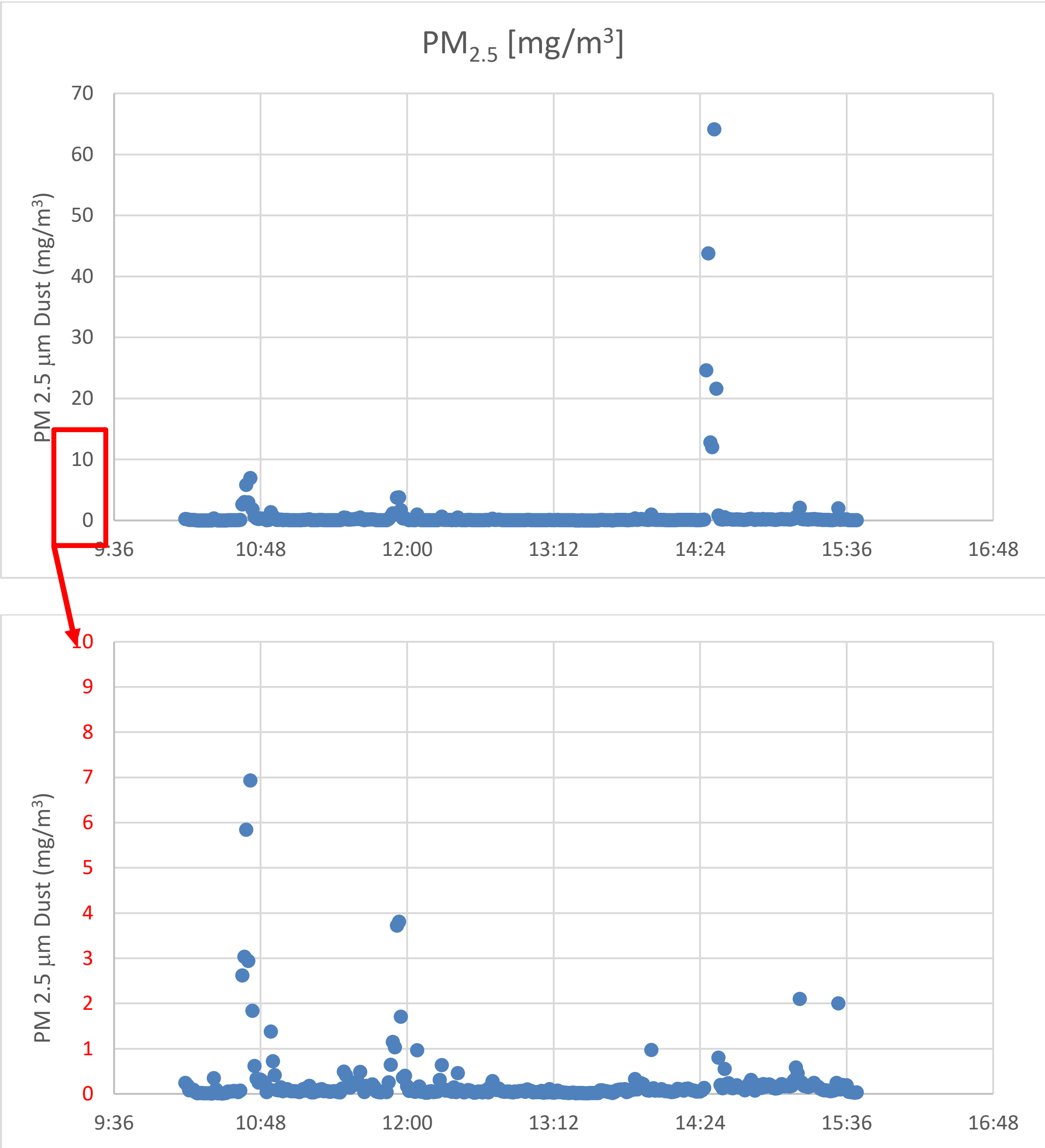

Figure 3: Real-time dust concentrations recorded for PM $_{2.5}$ size fraction across the work day positioned adjacent to a Laminating area (a **dry** process). Inset: reduced y-axis to clarify pattern of smaller peaks.

Peaks recorded at 10:30 am, 11:56 am and 2:00 pm correlated with observations of benchtop grinding. Immediately following the edge grinding, smaller peaks (e.g. at 11:59 am) were recorded corresponding to dry compressed air blowing (or 'cleaning') the benchtop. The large peak recorded at approximately 2:40 pm appeared to have correlated to the observation of a work colleague using the compressed air to clean his clothes and boots.

The results recorded by a TSI® SidePak™ Personal Aerosol Monitors (SN5201648004) which was positioned (fixed) adjacent to a Polishing area are shown in Figure 4. It shows the general respirable dust concentrations in the area where wet polishing occurred were typically lower than 0.1 mg/m^3. This is comparable to the respirable dust concentrations found for the personal monitoring of a worker undertaking wet Polishing/Edging as well as an adjacent static/fixed sample (see Table 2).

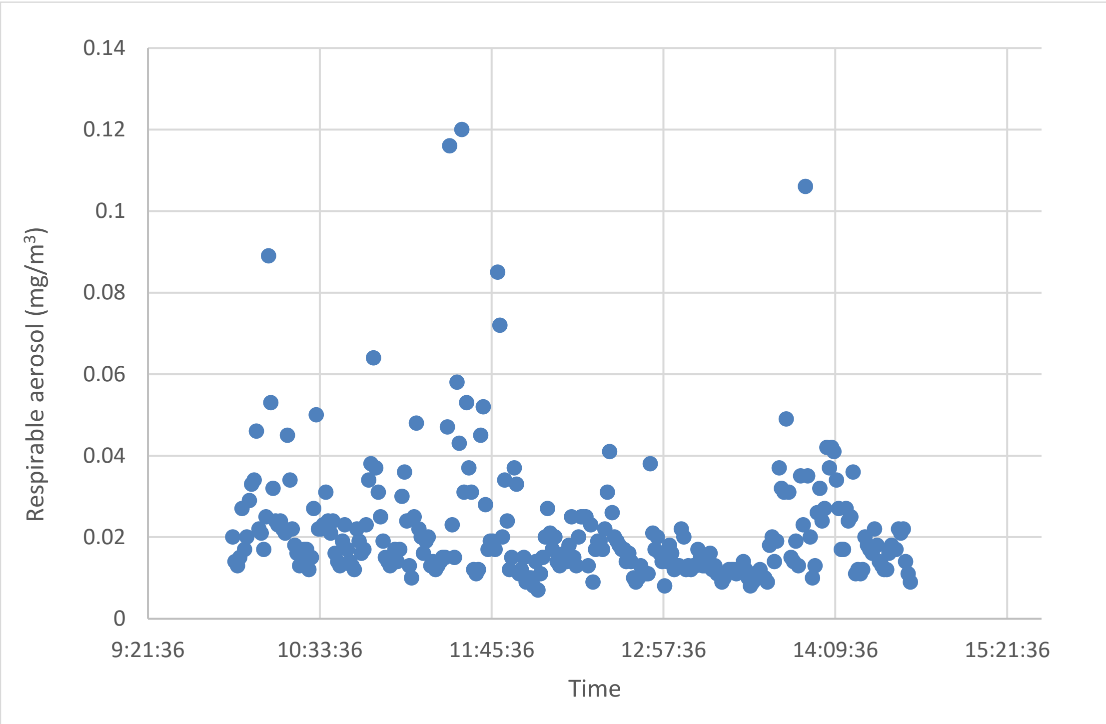

Figure 4: Real-time respirable aerosol concentrations recorded across the work day from a fixed positioned adjacent to the Polishing area (predominantly wet process).

During installation of engineered stone products, instantaneous dust measurement was simultaneously measured for mass (mg/m^3) and size fraction (PM $_1$, PM $_{2.5}$, PM $_4$ (respirable), PM $_{10}$ and Total PM size fractions, for short tasks such as cutting and edging (Figure 5). Small final modifications were sometimes required onsite during installation of engineered stone benchtops/splashbacks to fit the allocated space. Hand tools were typically used, and tasks often performed **dry**, or with limited water suppression (e.g. handheld spray bottles)**.**

While limited monitoring, and on some occasions limited 'dust exposure times' did not give significantly high TWA exposure results, it was observed that very high short term exposures do occur, especially with limitations on control measures in installation conditions.

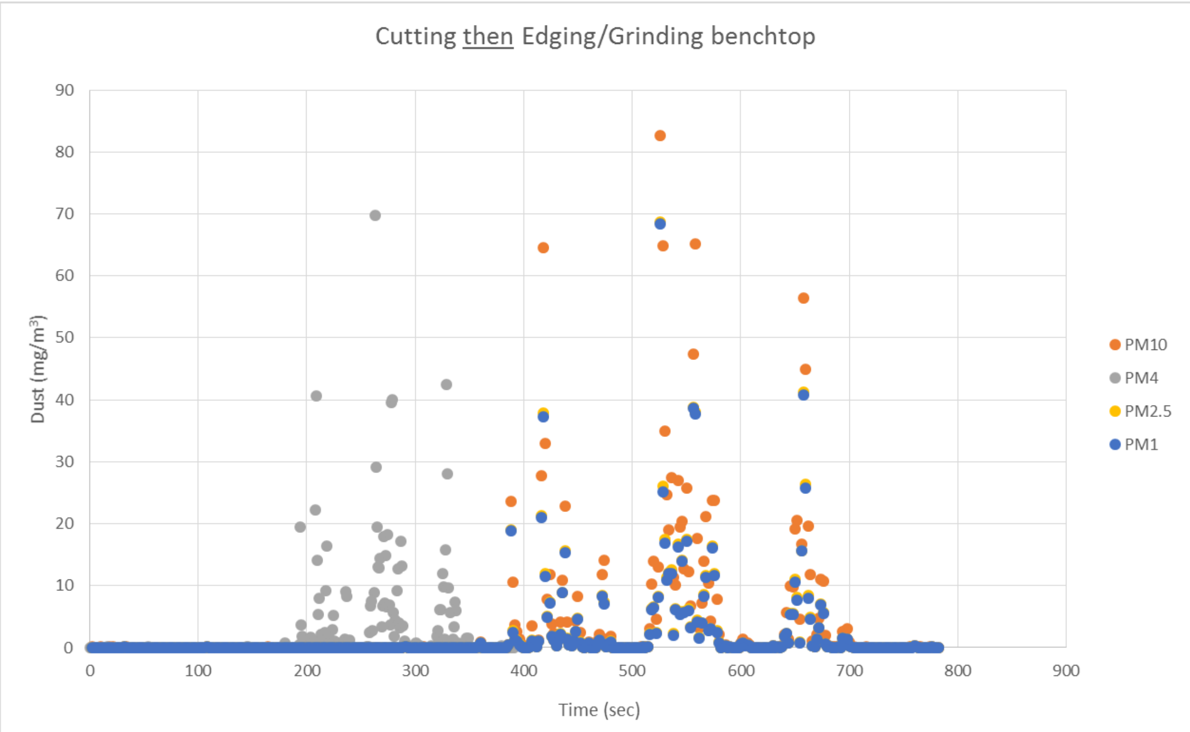

Figure 5: Real-time dust concentrations recorded for various size fractions (PM_{10}, PM_4, $PM_{2.5}$, PM_1) during installation processes such as cutting and edging/grinding engineered stone, performed **dry**.

9. Discussion of Results and Interpretation

Our results are consistent with findings from other studies, such as the USA. Initial workplace dust monitoring has identified work practices requiring improvement for exposure reduction.

The key findings included: One TWA result (laminating operator, dry) was well in excess of the current RCS Workplace Exposure Standard (0.16 mg/m^3). Mean TWA exposures for edging/polishing operators were above half the exposure standard, even when using wet methods (and in one case, LEV). Foremen/supervisors walking around the factory floor and occasionally carrying out certain processes (generally wet) recorded exposures of 30 to 40% of the WES. CNC operators working with enclosed/partially enclosed machines and wet, had TWA exposures of around 0.02 mg/m^3 or around 20% of the WES. Even in an office adjacent to a work area within a fabrication plant, a TWA concentration of 0.2 mg/m^3 was recorded. Installation processes showed relatively low RCS concentrations, however observations and real time monitoring of the brief cutting/edging processes showed short-term high dust exposures are very likely and control measures such as appropriate usage of wet methods were not observed, even when cutting/edging was done outside. RPE was observed to be used. Further assessment of installers' exposure to respirable quartz is warranted during busy installation shifts, and controls and the correct use of RPE need further attention.

Real time dust monitoring shows the general respirable dust concentrations in the area where wet polishing occurred were typically lower than 0.1 mg/m^3. This is comparable to the respirable dust concentrations found for the personal monitoring of a worker undertaking wet polishing/edging. Real time dust monitoring showed high instantaneous levels for certain operations, notably dry cutting. These exposures may be masked if only conventional 8-hour time-weighted average exposure averages are reported, i.e. these short term high peaks may go undetected in TWA results. However, such exposures may be important in the development of accelerated silicosis, observed in Australian engineered stone workers. Dust controls should address the short term exposures (minutes as well as hours).

Whilst respiratory protective equipment (RPE) was provided, this was not adequately stored nor used by all workers observed. Education in the limitations and risk of wearing RPE was lacking. In some instances where poor storage was noted, the RPE could be increasing exposure. Control measures need to emphasise wet methods, use of effective local exhaust ventilation, the proper use of personal respiratory protection for particular tasks and good housekeeping in order to limit inhalation of resuspended dust. No medical surveillance program was in evidence. Health Monitoring is suggested in national guidance where exposures are not known and the substances have significant health effects or are not well controlled. The regulatory obligations to provide this to workers was not understood. Again, this may be due to the belief that wet methods are effective.

Of critical importance is that dry processing was common throughout the industry until recently. Therefore it is likely that many workers have been exposed to excess levels in the past, regardless of their current exposure. Experience elsewhere in Australia has shown that some workers with past exposure to dust from dry cutting have developed lung disease, with significant disability in some cases. It is important to identify cases of lung disease as soon as possible so that the workers affected can be referred for medical management. It is therefore essential that all workers in the industry, other than office staff, undergo health checks. This should also be available to workers with past exposure to dust but who have left the industry.
The health monitoring consists of:

- Completing a standardised questionnaire on respiratory health, and on work history and dust exposure,
- Lung function testing,
- Chest X-ray and possible CT scanning,
- Consulting with a medical specialist.

From an exposure science perspective, there are some further considerations, which may be relevant for the prevention of lung disease:

- Engineered stone products are relatively new products.
- They contain more crystalline silica than conventional monolithic stone (e.g. granite, marble).
- There is insufficient experimental toxicology and epidemiology on the composite materials to determine a short term exposure limit.
- Nano-sized particles may be more readily generated from the action of abrasion on a base material comprising smaller sized quartz particles, and further research is required to understand whether nanoparticles are a significant consideration in the exposure profile.

Particle size

The data obtained on dust particle size distribution appear to indicate that dust in the fabrication process was predominantly of respirable size (< 4 µm). Positional samples found to be in the fine range (≤ 2 µm) were from monitoring adjacent to the Polishing area, which was a wet process. Further classification of dust size characteristics, also considering ultrafine dust presence is warranted.

Conclusions

Interventions are required in this sector to reduce dust exposures and increase worker health monitoring. The scope of monitoring and interventions should also encompass on-site benchtop installation activities, where some dust control measures may be compromised due to site limitations.

10 Recommendations

On the basis of observed work practices, consultation and measured exposures, the following recommendations are made:

1. **Dry processing should cease.** This is based on the observation of extremely high RCS levels, which cannot be completely controlled with LEV.
2. **Where dry processing cannot be avoided, such as in-home interior installation, wet spray in conjunction with tool-integrated LEV and RPE (positive pressure air purifying device) should be used.** PAPR provides a high level of protection and is suitable for persons with beards.
3. **Dusty processes should be isolated from general work areas.** This is to prevent unnecessary exposure to office staff and bystanders.
4. **Fabrication processes should be enclosed as much as practicable, consistent with good occupational hygiene practice.** Lower exposures were observed for enclosed machines.
5. **Effective wet methods for dust control must be used for cutting, grinding and polishing processes in a fixed fabrication facility.** While wet processes can be effective in reducing dust exposure, the effectiveness of this control may vary. A

water spray prior to grinding or cutting of the stone may be limited in effectiveness compared with full water application on the tool during processing.

6 **Local exhaust ventilation should be utilised for processes in a fixed fabrication facility.** This will allow for the capture of dust at the source.

7 **A high level of housekeeping is needed, and wet cleaning methods or high efficiency particle filtration (HEPA) vacuum methods should be applied. Compressed air clean-up should not be used.** This is to prevent resuspension of settled dust.

8 **Where personal protection is provided in the form of a half face or full face dust mask (negative pressure air purify respirator), this should be individually fit tested, and training provided to the worker.** Simply providing respirators is not sufficient.

9 **Specific worker training should be provided.** The understanding of RCS exposure pathways and health implications (e.g. exposure from contaminated clothing), limitations of RPE (including the need for proper fit testing, storage and maintenance) should be included.

10 **Health monitoring should be provided.** All workers in the industry, other than office staff, should undergo health monitoring. This should also be available to workers with past exposure to dust but who have left the industry.

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