THE UNIVERSITY OF QUEENSLAND

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Evaluation of Respirable Silica Dust Exposure from Asphalting Processes and Existing Controls

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Abstract:

The following report was completed by Masters of OHS Science student John Hwang. The project was supported by Fulton Hogan and the Australian Asphalt Pavement Association (AAPA). A comprehensive table was created to compile all relevant information on the currently used and additional recommended control measures for the mitigation of respirable crystalline silica (RCS) dust exposure in the asphalt paving industry.

The overall aim of the project was to evaluate RCS dust exposure in the Queensland asphalting industry – focusing specifically on the processes that generate RCS dust and the control measures that attempt to minimise exposures.

The project objectives were to:

- Observe and identify key activities in the asphalting process that generate dust that may contain RCS.
- Observe and identify which workers/roles may be exposed to RCS dust.
- Identify and understand the existing controls for RCS dust generation/mitigation and their effectiveness/use.

The most effective control techniques were the implementation of exhaust ventilation systems and water-sprays. Control measures currently utilised in the road-resurfacing industry were identified, in respect to the specific processes and plant/equipment.

Furthermore, potential issues with these existing and lacking control measures are discussed – providing recommendations for additional control measures and future action:

- Mandatory use of water sprays and exhaust ventilation systems on aforementioned profiling plant
- Ensuring water spray tanks are always filled via logistics
- Reducing the rev speed of tractor and skid-steer brooming processes
- Encapsulation of brooming heads and implementation of bucket bins during the design phase of brooming heads
- Use of wet cutting during loop cutting processes
- Continual usage of wet-cutting and local exhaust ventilation systems during core cutting
- Enforcement of proper respirator fit and standards

Further personal sampling should be conducted to provide a quantitative assessment of workers' exposure.

1.0 Introduction:

1.1 Aims & Objectives:

The overall aim of the project was to evaluate respirable crystalline silica (RCS) dust exposure in the Queensland asphalting industry – focusing specifically on the processes that generate RCS dust and the control measures that attempt to minimise exposures.

The project objectives were to:

- Observe and identify key activities in the asphalting process that generate dust that may contain RCS.
- Identify and understand how the plant/equipment used generates RCS dust and factors that influence dust generation.
- Observe and identify which workers/roles may be exposed to RCS dust.
- Identify and understand the existing controls for RCS dust generation/mitigation and their effectiveness/use.

This project was completed jointly with another Masters of OHS Science student (Jason Nguyen) and was supported by host organisations Fulton Hogan and the Australia Asphalt Pavement Association (AAPA). The broad aim of identifying dust creating processes and key control measures was split into two projects. This project report focuses mainly on the review of control measures for dust mitigation and the other student's report focusses on the dust generating processes. Jointly a comprehensive table was created to compile all relevant information on RCS exposure in the asphalt paving industry. The two reports should be read in conjunction to obtain the full details of the broader study.

1.2 Rationale:

Occupational exposure to respirable crystalline silica dust (RCS) has become a significant concern recently, with major adverse health effects being associated with past exposure. The current asphalting process involves an extensive number of activities, which have the potential for overexposing worker's to RCS dust. However, there is a clear gap in literature pertaining to RCS dust in the asphalt industry – spurring the need for further investigation.

Additionally, a current contentious issue is the development of a suitable occupational exposure limit (OEL) for RCS. Typically, the OEL is presented as an 8-hour time-weighted average (TWA), which is the average airborne concentration of a particular substance permitted over an eight-hour working day and a 5-day working week. Achieving an OEL that is too low can become impractical, and an OEL that is too high may result in overexposure for workers. The Australian Institute of Occupational Hygienists (AIOH) recommends an OEL of 0.1 mg/m^3. However, there is recent consensus to reduce this limit to half (0.05 mg/m^3), in accordance with the United States' Occupational Safety and Health Administration (OSHA). These exposure limits are constantly under re-evaluation, typically a trade-off between practicality and the potential health risks involved with RCS. Further research is required to establish a limit with greater confidence.

There are a number of factors that make minimising RCS dust exposure difficult, including:

- Use of water spraying during profiling can drastically increase the duration from start to finish, as the ground needs to be fairly dry for asphalt to be laid – resulting in a trade-off between safety and performance.
- Water suppression on aggregate material mounds at processing plants can drastically increase the fuel consumption when creating the asphalt – resulting in a trade-off between safety and performance.
- Water tank capacity management is an often-overlooked issue. When Profilers and Suction Sweepers run out of water, they continue the job without the use of water suppression sprays – resulting in increased airborne RCS dust. Having to refill empty water tanks can be a time-consuming process, especially with projects with deadlines/targets.
- The (silica/quartz) composition of the profiled ground can vary significantly.
- Although asphalting organisations (e.g. Fulton Hogan, Downer, BCC) seem to use a similar fundamental process (profiling, sweeping, laying, compacting), the specific processes, plant/equipment and controls used can vary significantly, depending on the area/type of road (e.g. residential streets, highways) and other organisational differences.

Consequently, RCS dust generation, suppression and exposure can vary significantly from different roads and projects. Therefore, it is difficult to determine risk of exposure and simply 'fix' the problem. Part of the process moving forward is to identify and communicate the complexity of the problem. With the evaluation of RCS dust in the asphalting industry being a fairly new topic of concern, the current project aims to provide a comprehensive starting-point through a collation of all the dust-generating processes, activities, plant/equipment and additional factors. The existing control measures will also be identified and assessed.

2.0 Literature Review:

2.1 RCS Exposure:

Asphalt roads are an essential component of city infrastructure and modern life and must be repaired as it ages. Even properly constructed and maintained asphalt roads will require reconstruction throughout its lifetime. The process of road reconstruction, from milling to adding the new asphalt, have the potential to generate vast amounts of respirable dust – including crystalline silica dust. Crystalline silica (SiO_2) in quartz form, is a very abundant mineral that is a significant component of most sands, soils and rocks (Safework AUS, 2019). Any mechanical construction processes, such as crushing, grinding and sawing, has the potential to generate airborne silica dust (Safework AUS, 2019).

The generation of RCS dust during mechanical processes has become a major concern recently, as various adverse health effects have become recognized as being caused by occupational exposure. RCS dust has been shown to have a number of adverse health effects, such as irritation of the respiratory tract, fibrosis of the lungs, silicosis and lung cancer (Bang et al., 2010; Linch et al., 2002; Leso et al., 2019; Rooijackers et al., 2016). The chemical and physical characteristics of the airborne particle greatly influences the physiological effect (Rabolli et al., 2011). For example, the size and aerodynamic diameter of the inhaled particle is indicative of the extent of penetration and deposition into the respiratory tract. A particle with an aerodynamic diameter of less than 10μm has the ability to penetrate and deposit in the alveolar regions and lower bronchioles of the lungs. This deposition of RCS dust is widely recognised for having a strong association with fibrosis of the lung tissue and silicosis, a progressive condition marked by irreversible scarring of the nodular regions of the lung (Rabolli et al., 2011; Davis, 1986). Consequently, minimising occupational exposure to RCS dust is a significant health consideration.

Additionally, almost 590,000 workers in Australia were exposed to occupational RCS dust in 2011 (Cancer Council, 2016). An estimate proposes that about 5700 of these workers will develop lung cancer due to RCS dust exposure. A study by Poinen-Rughooputh et al. (2016) conducted an epidemiological meta-analysis on the risk of lung cancer from occupational exposure to RCS silica dust, pooling eligible cohort and case-control studies. Results strongly suggest the carcinogenic role of RCS dust on the lungs, with higher exposures reflecting a higher risk (Poinene-Rughooput et al., 2016). Additionally, the International Agency for Research on Cancer (IARC) has classified crystalline silica as Group 1 – a definite carcinogenic risk for humans. Although many studies suggest the carcinogenicity of crystalline silica dust on the lungs, a definite conclusion remains rather controversial (Kim et al., 2018; Chen & Sun, 2007).

Many confounding factors/chemicals and the long-latency period of lung cancer risk make it often difficult to study the direct physiological effect silica has. Tobacco smoking is one of the most established causes of lung cancer (Furrukh et al., 2013; Pesh et al., 2012; Walser et al., 2008). Even with the increased awareness on the carcinogenicity of smoking, a large percentage of blue-collar workers, specifically in construction, still smoke (Hong et al., 2014). Consequently, smoking is a significant confounder for studies investigating the lung-carcinogenicity of RCS dust in the construction industry (Richardson et al., 2010). Other recognised agents in the construction industry that increase lung cancer risk are asbestos and diesel engine emissions (Lacourt et al., 2015; Silverman, 2017). Notably, asphalt and tar exposure has also been linked to lung cancer risk, to a lesser extent (Kriech etla., 2018; McClean et al., 2011). Therefore, there are many confounders that potentially reduce the reliability of studies on RCS dust and lung cancer risk. Nonetheless, the majority of epidemiological studies suggest a strong association between RCS dust exposure and increased lung cancer risk – spurring the need for further research on the construction processes that generate RCS dust and the existing controls that attempt to minimise exposure. Specifically, RCS generation and exposure in the asphalting industry is a fairly recent issue – thus, poorly researched.

2.2 Asphalting Processes that Generate Dust:

Fundamentally, the asphalting process involves the road resurfacing using asphalt milling machines, followed by sweeping/brooming the mills ground via tractor brooms and suction sweepers, followed by laying of hot asphalt, which is then compacted (Hammond et al., 2017). These processes can generate large amounts of dust, especially when dust suppression measures are not utilised properly (Linch et al., 2002). In addition, mechanical processes which transfer more energy to the silica-containing material, have a greater potential to generate more airborne RCS dust of smaller respirable fractions – thus, posing as a greater health risk for workers exposed (Meeker et al., 2015). Hammond et al. (2016) investigated RCS exposure on eleven asphalt milling sites, conducting full-shift personal sampling (n = 42) for workers and evaluating existing dust-suppression controls. It was determined that all workers sampled had exposures well below the National institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) of 0.05 mg/m^3 – indicating that the ventilation and water-spray controls were capable dust-suppression controls. However, the observations and sampling results could have been subject to atypical, increased compliance/use of control measures during the ten days of research – a possible limitation of the study.

A similar study by Linch (2002), found contradicting findings to Hammond et al. (2016). After conducting personal sampling for RCS dust on asphalt milling workers, Linch (2002) found that workers had exposures significantly higher than the NIOSH REL of 0.05 mg/m^3 – suggesting existing dust suppression control measures were not effective. Similar findings were observed by Valiante et al. (2004), who conducted personal sampling for 52 workers (n = 52) from nine highway repair sites, involved in six major highway road repair tasks – operating a jackhammer, sawing concrete, milling concrete, cleaning concrete/roads, milling asphalt and cleaning asphalt. Sampling found that workers involved in all major tasks, except milling and cleaning asphalt, elicited overexposure to RCS. Notably, water dust-suppression was not used due to costs involved with clean-up and reduced construction material performance with its usage (Valiante et al., 2004).

Therefore, it is evident that the processes and control measures involved in the asphalting process can vary significantly between different organisations, depending on the type of road being operated, safety-performance trade-off and workers' compliance. These unstandardized methods make it difficult to research relative exposure to RCS dust in the asphalting industry, as well as the effectiveness of existing control measures.

2.3 Preventative Control Measures for RCS Dust:

Acknowledging the risks involved with RCS dust, WHS Regulators and organisations have been targeting action to minimise workers' exposure through risk management plans and various control measures, in accordance with the Hierarchy of Controls (Figure 2.1). The Hierarchy of Controls emphasises the importance of isolating the workers from the hazard (RCS dust) and engineering measures that minimise RCS generation; followed by less effective and reliable, yet important, administrative measures and personal protective equipment (PPE).

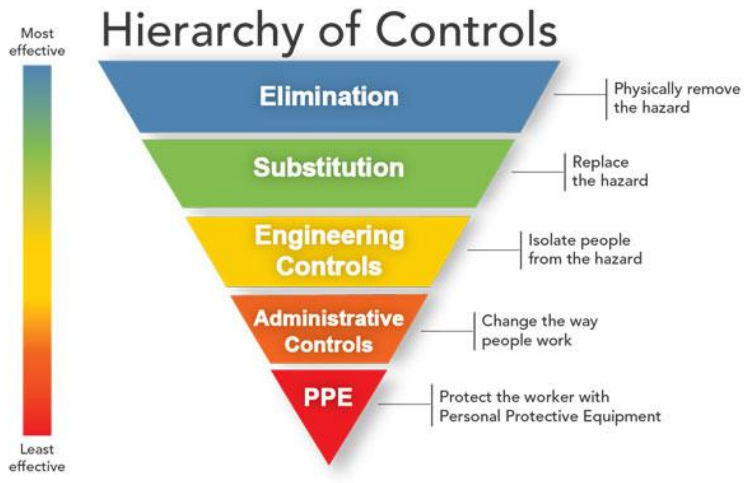

Figure 2.1: Hierarchy of Controls, depicting levels of effectiveness and reliability.

The primary goal for minimising exposure to RCS dust is to prevent the formation and suspension of dust into the air. There are many activities in the asphalting process that generates airborne dust. Examples include: the production of airborne dust through milling of the road and asphalt test core-cutting; the dispersion of dust via the transportation of milled material/aggregate; and the resuspension of dust from tractor brooming and movement of vehicles (Hammond et al., 2016). Consequently, a number of preventative control measures are required to minimise workers' exposure to RCS dust.

A widely accepted engineering control measure that has been shown to greatly minimise the generation of dust, is water suppression systems (Beamer et al., 2005). Water suppression techniques are currently used in a number of major tasks in the asphalting process – including water sprays on profiling cutter drums and conveyers (Figure 2.2) (Linch et al., 2002). A study by Meeker et al. (2009) observed a statistically significant 91% reduction in RCS dust exposure in wet saw concrete cutting, when compared to dry saw cutting. Many other studies have emphasised the effectiveness of water suppression of RCS dust (Beamer et al., 2005; Cooper et al., 2015; Meeker et al., 2009).

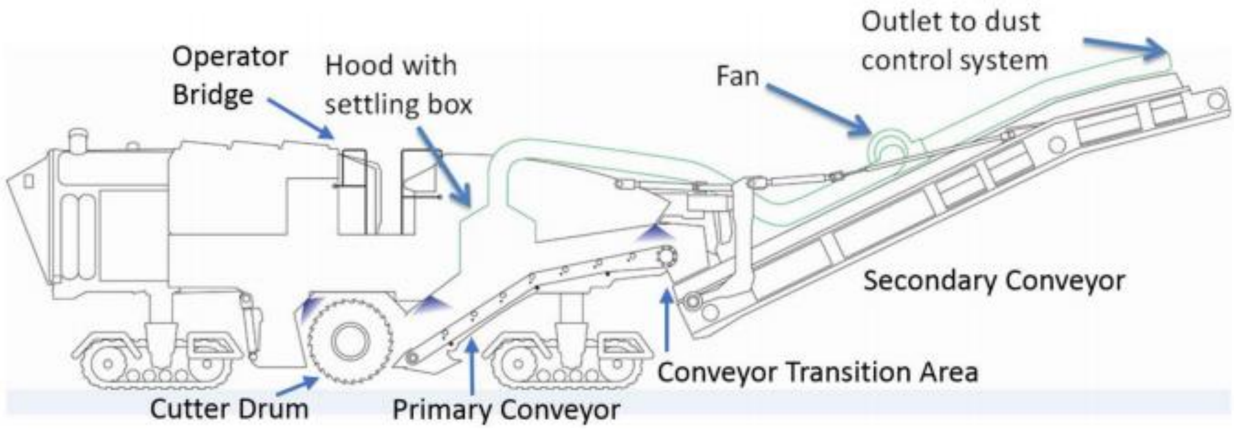

Figure 2.2: Large pavement profiling plant, showing key areas for dust generation and suppression (NIOSH, 2019).

Another equally important engineering control measure is ventilation systems (Middaugh et al., 2012). Ventilation measures on profiling plant focus on enclosing the drum housing and conveyers (Figure 2) and proper duct and hood design (Hammond et al., 2016). To contain RCS dust at the source of dust generation (milling saw), ventilation systems remove air and maintain negative air pressure in the drum housing of the profiling plant (Hammond et al., 2016). Another control for minimising worker exposure to RCS dust is enclosed operating cabs on vehicles, such as Skid steers/Bob-cats (Linch et al., 2002). Notably, enclosed cabs are not used for many profiling plant operators, potentially due to the associated communication and visual limitations (Middaugh et al., 2012). These are all effective controls that are often used in tandem with water suppression systems to minimise RCS dust generation.

Respiratory protective equipment (RPE) is an effective, but unreliable, control for minimising workers' exposure to RCS dust. RPE cannot be relied upon due to proper fitting issues and workers' tendency to remove RPE during their shift (Linch et al., 2002). Facial hair and atypical facial structure have been shown to reduce the effectiveness of respirator significantly, through poor sealing/leakage of air (Han & Kook-Lyeol, 2003; Floyd et al., 2018). Notably, this is an ethical issue, as workers are required to have cleanly-shaven facial hair for the facial masks to be effective. Most commonly, P2 particulate filter, half-face masks are used as an effective RPE for RCS dust (WorkCover QLD, 2019). Fit-testing should be conducted for all workers to test the seal of respirators (Hammond et al., 2016).

In conclusion, there is an obvious gap in literature regarding RCS dust exposure in the asphalting industry. The adverse health effects from RCS dust exposure is extensively researched, however, further research is required to validate these claims. Nonetheless, epidemiological data strongly suggests overexposure to RCS dust is linked to fibrosis of the lungs, silicosis and lung cancer. Water dust suppression and ventilation systems are effective methods for reducing RCS dust, however, further investigation is required for evaluating the control measures used on asphalting plant/equipment, as well as the activities which generate RCS dust.

3.0 Methodology:

The current project utilised an observational study design conducted over a fourteen-week period (29th July 2019 – 11th November 2019). Predominately qualitative data was collected via interviews with various participants and employees from major Brisbane-based asphalting organisations, including: Fulton Hogan, Downer and Brisbane City Council (BCC).

Specific sites/projects that were visited included:

- Brisbane's New Parallel Runway Project, *Brisbane Airport* (Fulton Hogan)
- Gateway Motorway Upgrade Project, *Eagle Farm* (Fulton Hogan)
- Ormeau Asphalt Plant, *Stapylton* (Fulton Hogan)
- Stonemaster Quarry, *Stapylton* (Fulton Hogan)
- Blue Rock Quarry, *Cedar Creek* (Fulton Hogan)
- Brisbane City Council Asphalt Plant, *Eagle Farm* (BCC)
- Residential Street resurfacing projects (BCC)
- Loop Cutting Project, *Tallebudgera* (Downer)
- Downer Archerfield Asphalt Plant, *Archerfield* (Downer)

Employee roles interviewed included: plant/equipment operators, project spotters, supervisors, engineers and safety managers. Evaluation of dust-generating processes was made using visual observation, photos and videos. Qualitative data was collected to answer the following:

- What are the activities involved in the asphalting process that generate RCS dust?
- What are the plant/equipment generate RCS dust?
- How is RCS generated?
- Which workers/roles are exposed to RCS dust?
- How are workers exposed to RCS dust?
- What is the typical duration and frequency of exposure?
- What factors increase/decrease RCS dust generation?
- What are the existing control measures attempting to mitigate RCS dust exposure?
- Are the existing controls adequate/used often?

Despite limited personal sampling data for RCS, some data was adopted from previous hygiene reports conducted by SIMTARS and BCC – provided by the host organisation. Hygiene data from these reports was from personal sampling of established similar exposure groups (SEGs) from the aforementioned asphalting organisations. Previously completed hygiene monitoring methods are in accordance with *AS 2985-2009 Workplace atmospheres – Method for sampling and gravimetric determination of respirable dust.*

The collected qualitative data was then collated into a comprehensive table, providing a summary of the activities and plant/equipment that generate RCS dust, workers who are exposed, and existing controls. This report focusses primarily on the RCS control measures – particularly the usage, problems and future recommendations. Ethically, some of the questions asked to workers were personal in nature. For example, they were asked about their typical work procedures and respirator use/compliance. Additionally, many photos and videos were taken to effectively document the processes and activities involved. Consequently, informed verbal consent was granted from all relevant participants.

4.0 Results:

Table 4.1 below provides a summary of the data collected during the project focusing on the identified current control measures and potential additional controls. The provided personal sampling data for RCS dust (8-hour TWA) was compared to the current Australian occupational exposure limit (OEL) for RCS dust (0.1 mg/m^3 for a 8-hour TWA) and the suggested/recommended OEL (0.05 mg/m^3 for a 8-hour TWA), for each similar exposure group (SEG) or operator/job role.

Table 4.1: Qualitative data depicting the major activities, plant/equipment, existing and additional controls, and dust sampling data (mean 8-hour TWA) compared to the current Australian OEL (0.1 mg/m^3) and the recommended OEL (0.05 mg/m^3).

Activity	Plant/Equipment		Existing Controls	Additional Controls / Issues	Dust Sampling Data Available – YES/NO	Compared to the OEL (0.1mg/m^3) – ABOVE/ BELOW	Compared to the Recommended OEL (0.05mg/m^3) – ABOVE/ BELOW
	Names/Synonyms	Make/ Model					
Profiling/ Milling	• Profiler • Miller • Cold Planer • Road Surfacer	• *Roadtec - RX300ex* • *Wirtgen - ARPS03*	• Integrated water dust suppression sprays inside profiling drum housing • Integrated water dust suppression sprays at primary conveyer • Integrated water dust suppression sprays at secondary conveyer exit • Ventilation control exhaust system at profiling drum housing • 'Sock' valve on secondary conveyer →	• Water spray surfactants → added to water suppression sprays to increase binding of dust to water. • Water flow meters and pressure gauges on the profiler to provide a visual indicator that water spray systems are operating. • Enclosed operator cabin	YES	BELOW	ABOVE

			indicates that ventilation system and water suppression sprays are in use. • Half-face P2 respirator				
	• Mini-Profiler • Bobcat w/Profiler Attachment • Bobcat w/ Wheel Saw Attachment	• *Coneqtec AP-450HD* Road Profiler Head • *CASE SR250* Skid Steer • *Bobcat S630*	• Physical hood enclosure • Enclosed operator cabin	• Exhaust ventilation on drum enclosure • Supplemental water sprays for dust suppression • Water combined with surfactant	YES	BELOW	BELOW
	• Jackhammer	• *Bosch – GSH27VC*	• Half-face P2 respirator	• Water suppression on drilling surface	NO	NA	NA
Cleaning	• Tractor Broom, • Power Broom, • Tractor w/ Power Broom Attachment	• *John Deere - 4720*	• Enclosed operator cabin	• Power broom head is not fully enclosed over the top. • Power broom head does not have a bucket bin for debris to be deposited. • Implement ventilation system/extraction	NO	NA	NA
	• Bobcat w/ Bucket Broom • Skid Steer w/ Bucket Broom	• *Bobcat - S630*	• Enclosed operator cabin • In-built bucket bin to collect dust/debris		NO	NA	NA

	• Suction Sweeper • Road Vacuum Sweeper	• *Macdonald Johnston* FG15277	• Water sprays to reduce recirculated dust • Suction mechanism to collect wet dust/debris • Enclosed cabin		YES	BELOW	BELOW
	• Blower	• *Echo PB - 255LN*	• Half-face P2 Respirator	• Substitute: Suction vacuums should be used instead of blowers to remove settled dust	NO	NA	NA
Spray Sealing	• Bitumen Sprayer • Asphalt Sprayer	• Fulton Hogan bitumen sprayer FHS3	• Exclusion zone (15m radius from sprayer)		NO	NA	NA
Core Testing	• Core Cutter	• JMT202	• Local exhaust ventilation (LEV) system		NO	NA	NA
Loop Cutting	• Road Saw • Vacuum w/ HEPA filter	• *Husqvarna - FS 400 LV*	• Separate vacuum w/ HEPA filter used to collect loose dust and debris after cutting. • Half-face P2 Respirator	• Wet cutting is not used as it affects the seal that is applied after cutting.	NO	NA	NA
Laying Asphalt	• Asphalt Paver • Manual Shovel	• *Roadtec RP-195ex*	• Half-face P2 Respirator (NOT mandatory)	• Respirator use is not mandatory	YES	BELOW	BELOW
	• Bobcat w/ Spreader/Leveller	• *CASE SR250* Skid Steer Loader	• Enclosed operator cabin		YES	BELOW	BELOW
	• Roller	• *CAT - CB24B*	• Exclusion zone (3m radius)		NO	NA	NA

Note*: Refer to Appendix A.1 for representative photographs of plant/equipment as well as rough field notes

Table 4.2: Engineering control measures for specific plant/equipment recommended by the American National Asphalt Pavement Association (NAPA), compared with control measures currently used by QLD Asphalting Organisations.

Plant/Equipment	Recommended Engineering Control Measures by NAPA	Currently Used by QLD Asphalting Organisations (YES/NO/PARTIAL)
Profiler (full-size)	• Exhaust ventilation on drum enclosure • Supplemental water sprays for dust suppression • Ensuring constant supply of water • Water combined with surfactant	• YES • YES • PARTIAL • YES
Mini-Profiler	• Exhaust ventilation on drum enclosure • Supplemental water sprays for dust suppression • Water combined with surfactant • Enclosed cabins (see below)	• NO • NO • PARTIAL • YES
Jackhammer	• Water delivery system that supplies a continuous stream or spray of water at the point of impact OR • Equipped with commercially available shroud and dust collection system.	• NO • NO
Tractor Broom	• Enclosed cabins (see below)	• YES
Skid Steer w/ Bucket Broom	• Enclosed cabins (see below)	• YES
Loop Cutting walk-behind saws	• Integrated water dust suppression system that continuously feeds water to the blade.	• NO
Enclosed cabins	• General housekeeping to minimise settled dust • Cabin door has an effective seal • Under positive pressure maintained through continuous delivery of fresh air • Intake air is filtered through a 95% efficient filter (in 0.3 – 10 µm range). • Heating and cooling capabilities	• PARTIAL • YES • YES • PARTIAL • YES

5.0 Discussion & Recommendations:

5.1 Comparison of Personal Sampling Data with the Current and Recommended OEL:

Despite limited personal sampling data for RCS dust, it can be seen that no job roles/SEGs, that were assessed, exceeded the current Australian OEL of 0.1 mg/m^3 for an 8-hour time-weighted average (Table 4.1). However, with recent debate and recommendation on reducing this OEL to 0.05 mg/m^3, it is necessary to compare data to this more stringent limit. As seen in Table 4.1, only the profiling crew (i.e. profiler operator, level hand, profiler supervisor) elicited a mean exposure greater than the recommended OEL of 0.05 mg/m^3. This suggests that the profiling crew had the greatest exposure to RCS dust during the road re-surfacing project under assessment. However, due to the extremely small sample size, there is little reliability in the findings. Nonetheless, current control measures and work procedures should be reassessed, in an attempt to minimise RCS dust exposure.

A major limitation of this study was the lack of personal sampling data for each respective project role/SEG. Further quantitative assessment of RCS dust exposure is required – a significant priority for the management of RCS exposure in the asphalting industry.

5.2 Controlling RCS Dust Exposure during Profiling Processes:

Ventilation systems are an essential engineering measure for controlling RCS dust exposure during asphalting processes. As seen in Table 4.1, in-built ventilation systems were observed in a number of plant/equipment. The Profiler utilised an exhaust ventilation system in the cutting drum enclosure.

To understand how the ventilation system helps control RCS exposure, design considerations should be understood. When designing a ventilation control on a profiler, the following considerations should be made (NIOSH, 2015):

- Extent of enclosure around cutting drum enclosure and conveyers (Figure 2.2)
- Hood and duct design
- Measures to prevent clogging of ventilation system
- Required airflow capacity

Most important, is preventing the escape of RCS dust from the cutting drum enclosure. Thus, the cutting drum enclosure on a profiler should be designed to provide maximum isolation from the outside, with only an opening at the top to allow profiled asphalt product to be transferred to the dump truck (NIOSH, 2015). Furthermore, removing the open space in the cutting drum enclosure would help maintain negative air pressure, necessary for RCS dust containment.

ACGIH (2013) suggests that the water spray nozzles in the drum enclosure can result in positive air pressure – unideal for RCS dust containment. Additionally, the rotating cutting drum can generate air flows that can increase the 'leakage' of RCS dust from the drum enclosure. This further stresses the importance of exhaust ventilation systems to prevent RCS dust from escaping out of the drum enclosure, via maintaining negative air pressure (ACGIH, 2013).

The findings from the current investigation revealed that exhaust ventilation systems on full-sized profilers are mandatory, routine work procedures for all QLD resurfacing projects. However, exhaust ventilation systems were not utilised with the 'mini-profilers'.

Consistent with all observed road resurfacing projects, a mini-profiler was used to mill smaller areas of the road not accessible by the larger profilers. Notably, these mini-profiler heads (*Figure A.11)* did not utilise any exhaust ventilation systems or water sprays for the suppression of RCS dust generation. Additionally, the design of the profiler head also meant that the profiled debris had to be emptied from the head, often straight back onto the road. This process generated a large amount of visible dust, potentially exposing workers on-site. Therefore, it is recommended that the design of these mini-profiler heads be reconsidered – prioritising the implementation of exhaust ventilation and water spray systems.

Water sprays are considered the primary measure for controlling RCS dust exposure during profiling. The water sprays act by causing RCS dust and other material to increase in weight – ultimately reducing these particle's ability to become airborne (NIOSH, 2011).

A study conducted by NAPA & NIOSH (2018) found that the effectiveness of water spray systems to reduce RCS dust generation was attributed to:

- Increased water pressure
- Increased water quantity/flow
- Distribution of water via spray nozzle location and orientation
- Water surfactants

Of these factors, the distribution of water via nozzle location and orientation was found to be the most effective method for controlling RCS dust generation. Specifically, discharging the water in the opposite direction of milled material flow in the milling drum, significantly reduced the generation of RCS dust. Additionally, incorporating water sprays on the primary and secondary conveyor (Figure 2.2) minimised RCS dust generation (NAPA & NIOSH, 2018).

These findings indicate that with consistent use of engineering controls consisting of water sprays and ventilation systems are capable of controlling exposure to RCS dust generated during routine asphalt profiling processes. Nonetheless, the current investigation identified that industry use of these controls are inconsistent due to a number of various factors. For example, dust suppression water sprays are used sparingly, with the exception of the full-sized profiler, during the resurfacing of roads that require high quality controlling (e.g. highways, airport runways). This is because the asphalt spray seal cannot bind effectively to wet surfaces. On the other hand, this can be compared to resurfacing projects which do not require a stringent road seal quality (e.g. residential roads). These projects allow water sprays to be used more freely as an asphalt spray seal is not used/required.

Another consistency issue in the industry is the resupplying of water spray tanks on profilers and suction sweepers. Occasionally, the water spray tanks on the aforementioned plant become depleted, requiring quick refilling to continue the resurfacing project. If the logistics of refilling tanks are not managed effectively and quickly, continuation of profiling without water sprays was sometimes observed on projects with strict time constraints/productivity demands.

Another dust suppression technique is ‘wet drumming’. With wet drumming, water is supplied to the inside of the cutting drum onto the surface of the saw. This minimises the generation of dust in the cutting area (NIOSH, 2013). Both wet drumming and water sprays on profilers were utilised on all road resurfacing sites/projects (Table 4.1).

A notable control measure on all profilers observed was the use of a ‘sock’ valve, which gave a rough indication that exhaust ventilation and water-spray systems were operational. However, NAPA (2018) suggests the use of water flow meters and pressure gauges to provide a visual indicator that water spray systems are operating. This would be a more accurate and reliable indicator, compared to the current ‘sock’ valve.

5.3 Controlling RCS Dust Exposure during Brooming and Sweeping Processes:

The tractor brooming and skid-steer brooming process is one of the predominate sources of dust generation in the asphalt process. Notably, it was observed that the powered, rotary broom heads project the dust into the air in front/behind depending on the broom rotary direction. Additionally, this dust is distributed into the air, which then settles on the roads and nearby areas. Dust on road surfaces can re-suspend easily by traffic. Consequently, due to the large amount of dust generated and area covered by the power brooming process – engineering control measures should be implemented to minimise worker exposure to RCS dust.

Wetting the profiled ground before brooming/sweeping can significantly reduce dust generation (NAPA, 2016). However, spray seals and asphalt cannot be laid on wet surfaces, as it compromises adherence and durability. Therefore, wet dust suppression was never observed during tractor and skid-steer brooming.

Currently utilised control measures in the industry were largely limited to enclosed operator cabins. The objective is that with an effective seal and a continuous delivery of fresh air through ventilation systems, a positive air pressure can be maintained within the operator cabin (NAPA, 2016). Notably however, was the occasional non-routine opening of tractor broom and skid-steer operator cabins during other nearby processes (e.g. profiling) – compromising the isolation from contaminated 'outdoor' air. Additionally, NAPA (2016) suggests that intake air should be filtered through a 95% efficient filter (in the 0.3 – 10 µm range) – an additional consideration for organisations.

Perhaps the greatest issue regarding RCS generation from brooming processes is the rev speed applied by the operator. The rotary speed of the brooming heads is directly associated with the acceleration applied by the operator. Therefore, by reducing the vehicle revs, the broom head RPM can be reduced – ultimately minimising RCS dust liberation. However, this comes with a productivity issue, as reducing the vehicle revs would slow down the project as a whole. Nonetheless, by reducing project time constraints and utilising more plant, the speed required to complete the brooming task can be indirectly reduced – minimising RCS generation. A future consideration is the use of rev limiters on the skid-steers and tractor brooms – restricting the maximum revs.

Another additional control measure that can significantly minimise RCS dust generation from brooming activities is the implementation of bucket bins during the design phase of brooming heads. The skid-steer with the bucket broom attachment produced noticeably less dust than the tractor broom heads. This can be attributed to the dust/debris being swept and deposited in the bucket bin, instead of simply being dispersed outwards. In addition, the power broom attachments had an exposed front – providing more area for the dust to be dispersed. Encapsulating the whole broom head would potentially prevent dust projection away from the bucket bin. In conjunction, these design considerations could greatly reduce RCS dust generation and exposure from brooming processes.

5.4 Controlling RCS Dust Exposure during Asphalt Laying Processes:

From initial observation, the asphalt laying process seemed to be generating considerable amounts of visible dust. However, after further investigation, it was acknowledged that the visible 'plumes' were actually steam and fumes due to the asphalt having been heated to approximately 150°C (See Appendix A.2). Additionally, there is minimal generation of dust from already processed asphalt that is being laid. This is because the aggregate has already been coated in bitumen –

preventing RCS dust from being liberated. Nonetheless, personal sampling should be completed to provide a qualitative assessment of RCS exposure for workers involved in the asphalt laying process.

5.5 Controlling RCS Dust Exposure during Loop Cutting Processes:

The observed loop cutting project did not utilise wet-cutting – which elicited large amounts of uncontrolled RCS dust (Table 4.1). The only control measures used were a separate vacuum used in conjunction with the loop cutter, to collect any loose dust and debris from the road. The vacuum utilised was fitted with a HEPA filter, which was consistent with an M-class filter according to the AS/NZS 60335.2.69:2017. With the current OEL of 0.1 mg/m^3, an M-class vacuum is adequate. However, a H-class vacuum must be used for hazardous dusts with an OEL of <0.1 mg/m^3.

5.6 Controlling RCS Dust Exposure during Core Testing Processes:

Another exhaust ventilation system used in the asphalting process is during the core testing/cutting phase. Consistent with all sites visited, wet cutting (i.e. water applied at the cutting surface/saw) and local exhaust ventilation systems were utilised as a mandatory procedure/design (*Figure A.11 & A.12).* This can be attributed to the extensive research in the stone benchtop industry, resulting in the nationwide ban of dry-cutting (WorkSafe, 2019). This stringency should be incorporated into the road-resurfacing industry. Specifically, the use of water sprays during profiling processes should be mandatory.

5.7 Respiratory Protective Equipment:

Consistent with all observed sites/projects, a P2 half-face respirator was used by all full-size profiler operators, level hands, and all on-site workers in proximity of dust-generating processes (excluding operators in enclosed cabins). However, a significant issue was the enforcement of proper respirator fit practices and standards. Many workers had facial hair – known to compromise the protective seal of half-face respirators. Therefore, workers need to be clean-shaven and fit-tested to ensure a proper protection from RCS dust. Enforcement of respirator fit practices and standards is an important industry issue that needs to be addressed.

6.0 Conclusion:

The current study provided a qualitative evaluation of current control measures for minimising RCS dust exposure in road resurfacing processes. Provided personal sampling data for deemed to be insufficient for providing a reliable and conclusive quantitative assessment for RCS dust exposure. Consequently, further personal sampling and quantitative assessment of RCS dust exposure is required – a significant priority for the management of RCS exposure in the asphalting industry. There are a number of potential issues regarding sampling. These include:

- Difficulty defining specific SEGs due to,
- Non-routine work procedures, and
- Differences in profiled ground RCS content

Nonetheless, there are a number of additional control measures that can be implemented to minimise workers' exposure to RCS dust. These include:

- Mandatory use of water sprays and exhaust ventilation systems on aforementioned profiling plant (i.e. Full-sized profiler, Mini profiler)
- Ensuring water spray tanks are always filled via improvements in logistics
- Reducing the rev speed of tractor and skid-steer brooming processes
- Encapsulation of brooming heads and implementation of bucket bins during the design phase of brooming heads
- Ensuring proper sealing of enclosed operator cabins
- Use of wet cutting during loop cutting processes
- Continual usage of wet-cutting and local exhaust ventilation systems during core cutting
- Enforcement of proper respirator fit and standards

Further research should be conducted to investigate the relative effectiveness of these control measures, at reducing RCS dust generation.

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8.0 Appendices:

8.1 Appendix A – Photographs of relevant plant/equipment:

Figure A.1: Full-size profiler (Roadtec RX300ex)

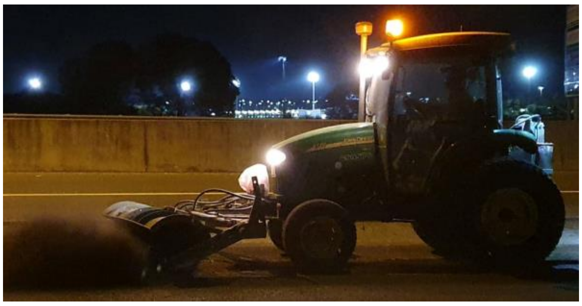

Figure A.2: Tractor broom (*John Deere – 4720)*

Figure A.3: Asphalt Paver (Roadtec RP-195ex)

Figure A.4: Bob-cat w/ Spreader/leveller

Figure A.5: Loop cutting road saw (*Husqvarna FS 400 LV)*

Figure A.6: Blower (*Echo PB -255LN)*

Figure A.7: Jackhammer (*Bosch – GSH27VC)*

Figure A.8: Suction Sweeper

Figure A.9: Mini-profiler

Figure A.10: Mini Profiler Head (Coneqtec AP-450HD Road Profiler Head)

Figure A.11: Core cutter 1

Figure A.12: Core cutter 2

8.2 Appendix B – Rough Field Notes:

DAY 1: (Mon 29/7/19)
Vehicle types:

- Sprayer (hot asphalt sprayed, 15m radius)
- Roller (3m radius from...)
- Profiler (drills into ground —> silica dust)
- Name (
- Name (brushes dirt/debris after profiler —> silica)

PPE —> fit testing P2 filter, brim hard hat, double line shirt

Book in WHITE-CARD appointment for Monday? (Bluedog website) -> let Michael/Keith know?
Before Brisbane Council visit next week Tues (week 2)

Day 2: good to have a First aid cert and Quality Auditing diploma

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Week 2 Monday:

Skid steer: has some water small profiler + brush for small maintenance repairs, isolated patching, Selective reconstruction of pavement depending on specific requirements -> deeper or shallower layers (deeper layers are clay)

Large profiler: 300mm max
Crushed concrete, crushed rock, bitumen, heated to make less viscous, Asphalt is heating then cooling to set, Concrete is waiting for it to set but reducing viscosity at the start.

Water used to protect cutting teeth.

Blending Material:
Continuous blending/Blending bins: dry material, dust coming out of baghouse means there's something wrong,
Batch Plants: Old method of mixing (combine everything in a wet method but can get
Material lasts 72hrs after heated

Profiling Process(aka Cold Planing): selective patches, choose depth of profiling. Stone is coated in asphalt, seal bitchymen underneath with waterproof material, Overlay street: road sweeper/suction sweeper + water sprays,

Need dry surface for profiling for next stage
Weekdays 300-400 streets
Profiling to overlay separation
Split these two

TMJ need to do all at same shift
Profiling mill surface of road (old asphalt), recycle old asphalt, water sprays on profiliers and vacuum, water sprays on dump truck too, Not lubricating profiler teeth, profiler biggest dust generator

4-6hrs milling per shift continuous, 7-4 day shift + breaks and waiting and waiting for site to be safe, quarry is way more exp due to continuous,

Lab: core testing/cutting + wet cutting, lil bit asbestos but rare from previous buried material,

Sampling: Static tells if there is dust, Personal tells if its above/below OES, industry discussion on dropping 0.02mg/m3 (WA,), however outvoted for 0.05

Heat stress is a big issue (PPE vs heat stress)!!!!!!! Heat=sun+Asphalt heat

Total ban on dry cutting of silica

Sealing after profiling with asphalty material usually only on High-traffic roads (where material might be more loose)

Sweeper Truck: Uses a lot of water and vacuum stored in the truck. Generates some dust from sweeping (See video)

25um test for dry materials (10%)

Baghouse:
Dry material store mounds use roofing/housing (control) and water spraying whenever it gets dusty
Exhaust hood: transports fumes from heating/mixing chamber/drum into the air filtration system
Filter bags systems in drum system to filter dust
Exhaust after air is filtered is monitored twice a yr for hazardous chemicals/fumes/vapours and an internal dust sensor in the

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WEEK 3: Downer gc visit

Archerfield quarry= higher aggregate of quartz
They don't let take a core out of road -> dunno what the ground is made of

Mortar mixing = covered in dust
———————————————————————------------------------------------

TUESDAY 27/08/19

Tracker Brooms:

- 'Power broom' attachment: Two types (john deere mechanically direct driven) - lower speed to lower dust). Hydraulic is related to rev (PDO pump mounted)
- Wind direction should be taken into consideration
- Profiler operator p2 half face respirator
- Profiler dust generation: from conveyer too. CONTROL: enclosed conveyer with vacuum fans/filters. Recommendation is to reduce speed of conveyer. Water spray usually only at drum/cutter area which is enclosed, sometimes water spraying on conveyer but not when we went/saw.
- Video 1,2: dry profiled ground indicator that no water was used, however in vid 2 can see ground becomes wetter indicating he started using water
- Video 3: tractor broom does not use vacuum or water, just the mechanical power/direction of the broom into the storage
- Video 4: profiler dust- workers stan
- Power broom (tractor brooming) does not have a bin where dust is collected. Skid steer w/ bucket broom (tractor brooming) DOES have a bin. Therefore, skid steer is alot better because it collects the dust instead of 'pishing it aside. Also, when the tractor broomer has more road space it tends to move faster.
- Photo: 'two socks' on profiler conveyer is a good indicator that the fan on the conveyer is sucking. If theres no material dropping from sock indicates fan/vacuum is on. Water dripping from sock indicates water sprays r being used
- S630 bobcat w/ broom and bin attachment
- Drawing dust - spraying - delivering dust

- Level hand (person watching from side) is within 1m of profiler (not 10m which is the exclusion zone from the toolbox talk)
- Skid steer mini profiler - has no vacuums no water suppression. Only control (for operator) is the enclosed cabin. Profiled material is left behind on ground, not collected like the big profiler
- Some workers have not done fit testing, bad fit indicated by fogging of glasses
- Tack truck - sometimes uses compressed air/or jackhammer to clean up side of road which generates alot of dust
- People on site/exposed: Project engineers, Inspectors, Spotters, foreman, general crew, Level hand
- Last truck (Suction Sweeper) - controls: water sprays on side + vacuum, some sort of filter
- Water storage maintenance is another issue (sometimes they run out)

Control factors to consider: standing upwind from dust, speed of work (broom),

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MONDAY 2/SEPTEMBER:

Kubota B3150 (not fulton hogan)

$60k for bobcat
Power broom (tractor broom) and bob cat broom (brucket broom)
Spray sealer got tractor broom
Other uses bob cat broom
Bobcat S630
2half hr breaks

BCC TUESDAY (octief
5min exp
8hrvexposure
7-3pm, some 12hrs
Manual labor sweeping: 10min every 30min or so (probably most nonstop work in the operation)
Bobcat: enclosed cab
Roller: (not too dusty)
Team leader/Supervisor: every bit (bits of each exp). VERY RARE (exceptional reasons)
Short exp periodically to checkup/talk to profiler
Profiler: 5 people (2 level hand
Truck driver (dump truck): sometimes dont have window
Name for profiling —>"Road surfacing"
US vs AUS - atmospheric differences

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Golf brekky talk:

- Difficulty defining SEGs
- Non-routine tasks
- Differences in silica content

Brad: upper confidence limit UCL needs to be below 50%

TUESDAY - Downer Logan

- 2m width x 300mm deep
- Today only within 30cm from both sides
- People Exposed: traffic control, cone person, spotter, level hand,
- Small steel roller (roller)
- Residential side profiling -> 1/2 hrs to finish one street (depends on project)
- Bobcat with saw attachment -> mini profiling head does not use water suppression. Used to clean up edges
- Blower: blowing debris on edges
- FACTORS: Profiler cut width ("might use 1m profiler head instead of 2m for ease of mobility in residential streets)

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23/9/19 MONDAY
FULTON HOGAN BLUE-ROCK QUARRY

Asphalt Plant:

- Crushing plant: enclosed and misting
- Green big crusher plant -> makes road base
- Other crusher plant (exposed) -> makes aggregate

Crusher dust, 4mm, 5mm, 7mm, ...
Batch plant vs Drum plant
Yt video - double barrel drum mixer

Machine/Plant:

-
- Bobcat with saw attachment = cuts and cleans up edges
    - FACTORS: Width of attachment
    - CONTROLS:
- Blower
    - FACTORS: speed/intensity of flow
    - CONTROLS:
- Manual Brooming
    - FACTORS:
    - CONTROLS:
- Suction Sweep = a lot of dust no filters; has water sprays on side + vacuum
    - FACTORS: water storage maintenance (when they run out)
    - CONTROLS:
- Sprayer = hot asphalt sprayed
- Roller = not too much dust
- Profiler = drills into ground making silica dust airborne
    - FACTORS: Cut depth
    - CONTROLS: 'socks' as a visual indicator of suction being used on conveyer
- Tractor Broom (Power Broom) vs Bobcat with broom attachment (Bucket Broom) = brushes dirt/debris after profiling. Does not have a bucket
    - FACTORS: Hydraulics and Revs (lower speed to lower dust); DOES NOT use water relies on direction of broom into storage
    - CONTROLS:
- Skid Steer = small profiling (PROFILING HEAD ATTACHED) has some water + brush for small maintenance repairs; for isolated patching, selective reconstruction of pavement depending on specific requirements; some do not have vacuums or water suppression
    - FACTOR: has a bucket
    - CONTROLS:
- Core cutting/core testing = wet cutting vs dry cutting

    - CONTROLS:
- Sweeper Truck = some using water, has vacuum stored but can generate dust
    - CONTROLS:
- Shovelling

<u>Other Names:</u>

- Profiler/Road Profiling/Road Surfacing/Cold Planer/ Milling/Profiling
- Tractor broom/Power broom
- Bobcat with Broom = Bucket Broom
- Bobcat = Skid steer

<u>Possibly Exposed People:</u>

- Traffic Controller
- Cone Worker
- Possible Residual Dust from previous work
- Spotter
- Level Hand on side of profiler (manual adjustments)
- Project engineers, Inspectors, Foreman, General Crew = all exposed on site

<u>Controls:</u>

- PPE = fit testing, P2 filter, brim hard hat, double lined high vs. shirt
- Water = protects cutting teeth; dust suspension
- Total ban on dry cutting
- Enclosed Conveyor
- Enclosed Cabin
- Water Spray on drum/cutter area
- Brooming into the bucket
- Standing up-wind (to reduce exposure to dust)
- Lowering speed of work
- Vacuum/Suction