

AIOH Submission

Consultation on the prohibition on the use of engineered stone

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May 2023

Acknowledgements

The AIOH Council acknowledges the work of members who contributed to this submission from the External Affairs Committee: Kate Cole OAM (Chair), Professor Dino Pisaniello, Associate Professor Deborah Glass, Tracey Bence, Jeremy Trotman, Peter Knott, Dr Sharann Johnson AM and Shelley Rowett.

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Who we are

Occupational hygienists are the main frontline professionals who assess worker exposure to health hazards to prevent ill health through science-based investigation and testing of the efficacy of risk controls.

The [Australian Institute of Occupational Hygienists Inc \(AIOH\)](#) is the largest professional body for the scientists and engineers dedicated to protecting the health of workers in Australia. Established more than 40 years ago our members are at the coal face of health and safety assessment and risk reduction, working in metropolitan, rural and remote locations. We are in a unique position to understand the true nature of workplace health hazards and the efficacy of the protection against occupational illness provided to Australian workers.

The AIOH is the certifying body ensuring professional occupational hygienist competency and maintains registers of professional members and Certified Occupational Hygienists (COH)[®] to assist organisations seeking to engage the most highly skilled occupational hygienists.

Our mission is to promote healthy workplaces and protect the health of workers through the advancement of the knowledge, practice and standing of occupational health and occupational hygiene. The AIOH is a founding member of the International Occupational Hygiene Association and many Australian occupational hygienists are engaged in occupational hygiene research with international collaborators. The AIOH brings world-wide experience and insights on a range of traditional and emerging occupational hygiene issues.

Summary of our Submission

We welcome the opportunity to provide feedback on the policy options for the prohibition on the use of engineered stone. We have employed an evidence-based approach that considered many factors in coming to our conclusion on the options presented.

We consider that there is insufficient evidence to arrive at a discrete percentage of crystalline silica in engineered stone to underpin a specific cut-off for prohibition purposes. The figure of 40% crystalline silica used in Victorian regulation is an operational value, *inter alia* acknowledging the likely percentage of crystalline silica in granite. Based on the available literature and information, a percentage that is protective of worker health, or “safe” cannot be determined.

There are engineered stone products on the market with 10% or less crystalline silica, and there is evidence that the emissions from processing low silica products have correspondingly low respirable crystalline silica (RCS) concentrations. A value of 10% crystalline silica is evidently manageable by industry and incorporates a commonly accepted toxicological margin of safety for non-cancer endpoints. A cut-off of 10% crystalline silica (by weight) can be expected to keep *average* exposures to RCS below the Workplace Exposure Standard (WES) based on the weight of evidence from real world and academic studies. On the basis of existing product development activities, observed high emissions, and the hierarchy of hazard control, we recommend that processing engineered stone containing more than 10% crystalline silica be prohibited.

However, engineered stone containing up to 10% crystalline silica is not without risk. Accepting a value of 10% crystalline silica in engineered stone commits jurisdictional regulators and workplaces to a high degree of regulation and necessitates a high degree of compliance by employers and workers. It will also likely result in a high degree of reliance on the effective use of respiratory protection, something that has not been demonstrated to be successful in the engineered stone sector to date.

The precautionary principle is a guiding principle in decision-making that recommends that in situations where there is a potential risk of harm to health, precautionary measures should be taken even if the scientific evidence is uncertain or incomplete. The AIOH supports a precautionary approach that focuses on eliminating exposure at the highest level of the control hierarchy. Therefore, the AIOH is also supportive of a prohibition on the use of engineered stone, including a prohibition on the use of all engineered stone irrespective of its crystalline silica content.

We acknowledge that choosing to prohibit all engineered stone or if a specific percentage of crystalline silica is selected as a cut off, it will likely lead to modified or

new engineered stone products reaching the Australian market. It is paramount that policy makers anticipate and consider potential “new” or exacerbated health hazards that may arise from these products that may lead to occupational disease. We have included some areas of concern in our submission which we bring to the attention of policy makers and regulators, which are:

- The need to enact legislation to ensure that manufacturers declare the foreseeable emissions generated from processing engineered stone. The current process results in the employer being legally responsible for identifying all hazardous substances generated when processing engineered stone. It is unreasonable to expect an employer operating a small business to identify chemical substances which are not required to be listed in a Safety Data Sheet (SDS). Suppliers should be required to provide a full declaration of the toxicity of emissions generated while processing engineered stone, prior to it being able to be imported and used in Australia.
- We are concerned about the lack of accuracy of SDSs and suggest that mandatory standardised test methods should be imposed on importers to drive greater accuracy and information on the toxicological impacts of the dust arising from processing bulk materials.
- We are concerned about the increased use of recycled glass or other sources of amorphous silica, which will likely lead to greater exposures to freshly fractured silica particles. At present, the term “*non-hazardous*” appears in SDSs with reference to sources of amorphous silica which is not accurate nor appropriate for this hazardous substance.
- We recommend that consideration be applied to the future development of a Workplace Exposure Standard for respirable engineered stone dust. This approach would be similar to the one taken for wood dust and would ensure that all constituents of the complex mixture of engineered stone, such as various forms of crystalline silica, amorphous silica, pigments, resins and other materials are covered.

We wish to alert policy makers that further research, particularly toxicological research about the likely health effects of exposure to engineered stone dust is urgently required to ensure that future policy is evidence-based.

Introduction

The AIOH, alongside other professional associations and stakeholders, including the Australian Institute of Health and Safety, the Public Health Association of Australia, the Australian and New Zealand Society of Occupational Medicine, the Thoracic Society of Australia and New Zealand, the Lung Foundation, the Cancer Council of Australia and the Australian Council of Trade Unions, support a ban of high silica engineered stone. This level of precautionary action is appropriate following recent research conducted by Curtin University whose modelling estimated that banning engineered stone would result in a reduction of 100 cases of lung cancer and approximately 1,000 cases of silicosis into the future. [1]

We welcome the opportunity to provide feedback on the policy options for the prohibition on the use of engineered stone. Our previous submission provided evidence of the need for a prohibition as a complementary activity to other policy options. [2] This submission specifically addresses the concentration of crystalline silica that would trigger any prohibition on the use of engineered stone.

Three options are described in the Safe Work Australia consultation paper:

1. Prohibition on the use of all engineered stone;
2. Prohibition on the use of engineered stone containing 40% or more crystalline silica; and
3. Prohibition on the use of engineered stone containing 40% or more crystalline silica and licensing of PCBU's working with engineered stone containing less than 40% crystalline silica.

In writing this submission, we have adopted an evidence-based approach. This approach involved gathering and analysing scientific data and information relevant to the situation under consideration, in addition to that cited in our previous submission. [2] We acknowledge that additional unpublished information may be held and relied upon by other stakeholders in making their own submissions. If any new evidence pertaining to this subject emerges during the consultation process, we will consider whether it would substantially impact our recommendations.

This submission considers the following factors in coming to our conclusion on the options presented:

- The definition of engineered stone, the nature of the hazard, the relevant exposure science, at-risk occupations and exposure scenarios;

- The existing rationale for the cut-off of 40% crystalline silica as adopted by the Victorian WHS jurisdiction and the acceptability of this cut-off value;
- The likely percentage of crystalline silica in natural stone and disease prevalence from working with natural stone;
- Characterisation of airborne emissions from engineered stone when processed, including particle size, charge, and particle number;
- Emissions from engineered stone, including the anticipated occupational exposures when using products containing lower levels of silica;
- Types of silica in engineered stone;
- Toxicity of the non-crystalline silica constituents in engineered stone;
- Compliance practices; and
- The precautionary principle.

The nature of the issue

What is engineered stone and who is at risk?

Engineered stone is a formulated synthetic product also known as composite stone, manufactured stone, agglomerated stone, artificial stone, reconstituted stone or quartz conglomerate. It is:

- a) an artificial product that:
 - i. contains crystalline silica; and
 - ii. is created by combining natural stone materials with other chemical constituents (such as water, resins or pigments), and
 - iii. undergoes a process to become hardened; but
- b) does not include any of the following:
 - i. concrete and cement products (unless resins are included)
 - ii. blocks, bricks, and pavers
 - iii. ceramic and porcelain wall and floor tiles
 - iv. roof tiles
 - v. grout, mortar and render
 - vi. plasterboard.

The crystalline silica content in engineered stone varies widely. Commonly it contains greater than 90 per cent crystalline silica by weight, which is significantly greater than that found in nearly all natural stones.

Engineered stone is commonly processed for domestic and commercial use as bathroom and kitchen surfaces. There is an increasing use of engineered stone in other applications using silica-based composites such as skirting boards marketed as *"hygienic wall protection"* for use in the food/pharmaceutical industry and floor and wall coverings. [3] [4]

Workers are exposed to emissions from engineered stone when it is processed. There are at least four pathways by which workers may be exposed, these being:

1. Primary exposure – Exposure at short range (e.g. <2m) close to the source(s) of generation.
2. Bystander exposure – Exposure at a long range (e.g. >2 metres from the source), due to the long settling time for very small particles which were not captured at the source.
3. Secondary exposure – Re-suspension of settled dust (e.g. removing contaminated clothing, dry sweeping, use of compressed air for cleaning, dumping of waste in bins etc).
4. Secondary exposure – Inhalation of dust-containing mist particles in recycled water.

Stonemasons are a major group at risk of exposure to RCS. As a recognised trade, stonemasons comprise at least three sub-categories:

- a) monumental stonemasons engaged in the cutting, shaping and engraving of natural stone e.g. for headstones, statues, plaques;
- b) those engaged in cutting and laying stone blocks for the construction of buildings, stairways, monuments etc; and
- c) workers processing engineered stone, principally for benchtops destined for kitchens, laundries, bathrooms, etc.

Tradespersons within category c) are classified as stonemasons by WorkSafe Victoria. These stonemasons spend the majority of their time in a factory cutting, polishing, edging, etc. with powered hand tools, or operating water jet cutting or CNC machines. Others install the benchtops on site (also done by cabinetmakers) which may involve some cutting and finishing but significantly less than in the factory work. Workers may take on any or all of these roles within a week or over time. These differences in activities are reflected in the variation in RCS exposures.

Without considering the control measures implemented, the factory/workshop based engineered stone workers engaging in repetitive polishing are expected to have the highest RCS exposures depending on the type, frequency and duration of their work and the materials worked.

We note that engineered stone once installed, is unlikely pose a risk to health to homeowners unless it is further processed e.g. it is repolished.

Exploring the rationale for the 40% cut-off

There are challenges with assuming that a certain percentage of silica by weight in a product is “safe”. The argument for declaring a 40% cut-off is based on a comparison to natural stone and assumes dust from natural stone is not causing silica-related disease. This argument is flawed because:

- The type of emissions from engineered stone are qualitatively different from natural stone. These differences include, for example, the chemical composition (including organic resins and pigments), particle size, particle charge and crystalline silica polymorphs. The peer-reviewed literature suggests that these components may contribute to the type of accelerated silicosis seen in workers exposed to respirable engineered stone dust. [5]
- Natural stone varies in its silica content. Marble is typically <2% silica and moderate-silica products such as granite are typically ~30%, however a high degree of variability exists. [6]
- Cases of silicosis occur in workers who process natural stone [14] and in miners [7] exposed to minerals well below 40% silica. [8]

The threshold level of 40% crystalline silica content in the option presented is presumably drawn from the Victorian Occupational Health and Safety Amendment (Crystalline Silica) Regulations 2021 which imposes additional regulation (including licensing) of engineered stone containing 40% or more crystalline silica as a pragmatic cut-off point. The regulatory impact statement that supported the Victorian amendment regulations stated that “[t]ypically, benchtop materials such as marble, granite and concrete contain between 2 – 40 per cent crystalline silica, while engineered stones can contain as much as 95 per cent. Whilst silicosis has been around for a long time, increased use of engineered stone with its higher concentration of crystalline silica has meant exposure to silica dust has increased”.

While government sources report that granite contains up to 45% quartz [9, 10], the literature indicates that the true proportion of quartz in granite is typically less at 30%.

[11] [12] In addition, stonemasons seldom only work with granite, they may also work on lower-silica products such as marble.

Risks from granite dust exposure have long been studied in relation to stonemasons and silicosis. It is one of the few occupations to be historically exposed predominantly to quartz and be the subject of epidemiological investigation. A much-studied cohort in Vermont reported that following the implementation of dust controls post-1940, average respirable quartz exposures fell from estimates of $>0.1 \text{ mg/m}^3$ and stabilised to a mean of approximately 0.05 to 0.06 mg/m^3 in the 1950's. In 1996 an examination of approximately 600 retired Vermont granite workers found 25.9% of radiographs obtained from workers employed prior to 1940 displayed abnormalities (ILO 1/0 or greater), whilst in workers employed after 1940, only 5.7% of radiographs displayed abnormalities [13], demonstrating a lowered, but not eliminated, silicosis risk associated with long term reduction in exposure.

Hong Kong granite workers with silicosis have been medically examined since 1967. Exposure monitoring showed that they had been exposed to an average RCS exposure level of 0.48 mg/m^3 , with a mean percentage of quartz in the respirable dust samples of 48%. These exposures were associated with 45% of patients developing silicosis. [14] A follow-up of all employees [15] stratified by radiological classification revealed no opacities (ILO 0/0) in 177 workers with an average cumulative exposure of $0.69 \text{ mg}\cdot\text{m}^{-3}\cdot\text{yr}$. The authors noted these levels were similar to those reported in Vermont granite workers *"It is also interesting to note that the average level of silica exposure found among the silicotics in this study is only slightly higher than that reported for Vermont granite workers (2.6 cf $2.1 \text{ mg}\cdot\text{m}^{-3}\cdot\text{yr}$). The levels in non-silicotics is lower (0.69 cf $0.95 \text{ mg}\cdot\text{m}^{-3}\cdot\text{yr}$)."*

The average cumulative exposure for all Hong Kong silicosis cases was the equivalent to 0.06 mg/m^3 over 40 years. No radiologic opacities (ILO 0/0) were found in workers with average exposures equivalent of 0.02 mg/m^3 over 40 years. The Vermont workers with no radiologic abnormalities had an average exposure corresponding to 0.024 mg/m^3 per year over 40 years.

Silicosis presented a risk to stonemasons in Australia prior to the introduction of engineered stone. A study of compensated silicosis cases in South Australia between 1940 and 1987 identified that 10% of compensated cases related to stonemasons. [16] More recent statistics from iCare in NSW reported a prevalence of 3% of stonemasons who only worked with natural stone between 2019 and 2022. While higher prevalence of disease has been reported in engineered stone workers [17], the risk to natural stone workers is also not acceptable.

We also alert policy makers to the *All of Government* response to the National Dust Disease Taskforce Report which supported the elimination of silicosis among workers.

[18] We flag that selecting a percentage of crystalline silica that is “*acceptable*” for engineered stone on the basis it is no greater than that found in natural stone would be incongruent with the aim of the National Dust Disease Taskforce and indeed the Government’s objective of eliminating silicosis.

Emissions from engineered stone

Characterisation

Emissions generated from processing engineered stone versus natural stone are different both in particle size and behaviour once airborne. [11] [19] The toxicity of engineered stone emissions primarily relate to:

- a. the percentage, and type, of silica in the bulk material;
- b. the amount and type of emissions generated; and
- c. other constituents in the product.

We outline the importance of these factors in the sections below.

Percentage of silica in the bulk material

The high-silica content of engineered stone makes it difficult for usually effective control measures such as wet-cutting and ventilation to sufficiently lower exposures and protect workers from silicosis. Significant exposures to RCS occur over short-durations even when using wet-methods. [11] [20] [21] [22] Examples of recent studies include:

- A field study of occupational exposure to RCS in Northern Italy assessed four engineered stone fabrication facilities, all using wet processing methods. Occupational exposures to RCS were measured above the current workplace exposure standard (WES) of 0.05 mg/m³ in all facilities. [22]
- Another study evaluated commercially available tools and dust control measures when processing engineered stone and demonstrated that on-tool water suppression for brief cutting / grinding tasks (e.g. 30 minute duration) had the potential for significant RCS exposures. [23]

Additional lower-order control measures such as respiratory protective equipment (RPE) are therefore needed for silicosis-related disease prevention. While respiratory protection is a recognised control measure to protect workers from exposure to RCS, it requires a high level of commitment from both employers and employees to be effective. The employer must implement systems for fit testing (to ensure correct selection and fit) and to ensure RPE are correctly worn, stored and maintained over the long term, systems which have been largely absent from this sector.

Safe Work Australia Members recently determined that a new lowered WES of 0.025 mg/m³ measured as a time weighted average (TWA) will become effective, subject to an Impact Assessment, within three years. If enacted, this will be a fourfold reduction in the WES in 3-years. Such a quantum reduction in RCS exposures will require a greater focus on higher-order measures such as elimination of high-risk products. At present it appears that even the most regulated workplaces are still reliant on RPE to reduce exposure to RCS. [24]

A literature search was conducted to locate studies internationally where engineered stone was processed using wet methods and respirable dust and RCS concentrations were reported. The committee reviewed several peer reviewed publications to determine a predicted linear relationship between respirable dust and RCS on a weight basis (Figure 1). [20, 25-27] [28] [29]

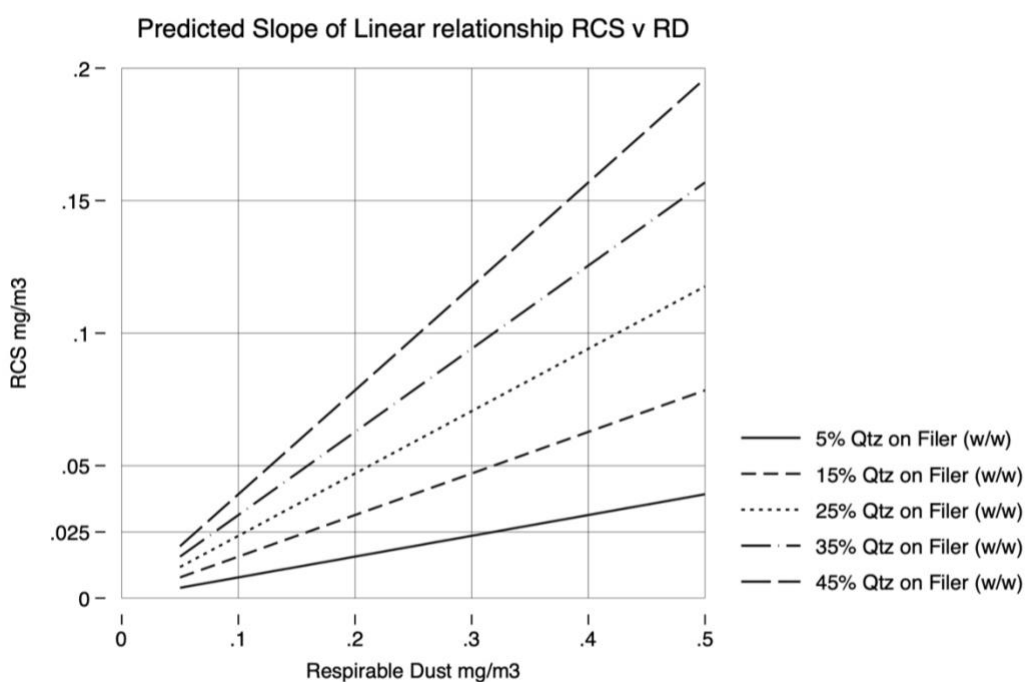


Figure 1 – Predicted Slope of Linear Relationship RCS v Respirable Dust

Figure 1 suggests that if the proportion of RCS in respirable dust was >15%, then RCS exposures were predicted to be above the proposed new WES of 0.025 mg/m³ for most respirable dust exposures above 0.1 – 0.2 mg/m³.

In the studies reviewed, the reported concentrations of respirable dust along with the reported concentrations of RCS were used to derive the percentage RCS on a filter. While the ratio between the percentage of crystalline silica in the bulk material and the percentage of RCS measured in respirable dust on a filter reported varied, a recent study suggested that crystalline silica in the bulk dust predicts that in respirable dust

generated during processing. [12] We assumed a 1:1 relationship between the percentage of crystalline silica in the bulk material to that on the filter.

To supplement the above analysis, we reviewed in-field studies conducted in Australia to ascertain what proportion of crystalline silica in the bulk product would result in average exposures below the new WES of 0.025 mg/m³.

Table 1 summarises Australian in-field studies where wet processing methods were reported. It presents the RCS exposure to workers with respect to the percentage of silica in the bulk material and provides a corresponding percentage of silica in the bulk material that would result in average exposures below the new WES.

Based on these studies, the proportion of crystalline silica in engineered stone should be no greater than 30% and preferably below 6% crystalline silica in the bulk product for the exposure to be on average, below 0.025 mg/m³

Table 1 – Calculation of % required in bulk material to achieve mean exposures below the new WES of 0.025 mg/m³ during wet processing (Australian data only)

Source	% by weight in bulk engineered stone	Measured mean exposure to RCS (mg/m ³)	Corresponding % by weight to reduce mean exposure <0.025 mg/m ³
[21]	64	0.1 - 0.12	13%
[26]	85	0.03 - 0.07	30%
[30]	95	0.02 - 0.37	6%

While we acknowledge the small sample size and high variability in Table 1, it is 'real world' RCS exposure data from Australian workplaces, which, coupled with the analysis of international studies, supports the view that the maximum proportion of crystalline silica in the bulk material should be less than 10% (by weight) if the aim is for average exposures below the new WES.

We recognise that a simple comparison of the percentage of crystalline silica in engineered stone omits the important toxicological factors of particle size, particle charge, type of silica and the presence of other constituents. However, the calculations are salutary.

Noting that there are engineered stone products on the market with 10% or less crystalline silica, a value of 10% crystalline silica is evidently manageable by industry. A value of 10% also incorporates a commonly accepted toxicological margin of safety for non-cancer endpoints.

Particle size, charge, and particle number of generated emissions

There are four studies of emissions from engineered stone which compared dry processing engineered stone to natural stone. [11] [12] [19] [31] All have shown differences in the amount of dust generated between granite and resin-containing engineered stone such as particle size distribution.

The processing of engineered stone results in the generation of ultrafine particles (nanoscale size $<0.1\mu\text{m}$) at a higher rate than from natural stone. [20] [32] These ultrafine particles are more likely to lead to inflammatory responses [33] which are a precursor to occupational lung disease. Studies also show the agglomeration of ultrafine particles. [19] [31] The surfaces of silica particles have intrinsic electrical properties and this may be modified by resin, which has its own electrical characteristics.

Workplace dusts typically consist of a mixture of dust particles varying in size. Whilst larger particles in the inhalable fraction can cause irritation to the upper airways, it is the respirable fraction of particles that is the main cause of long-term respiratory health effects. Unlike inhalable dust, the fine respirable dust cannot normally be seen with the naked eye when airborne. Figure 2 shows the relative sizes of small particles.


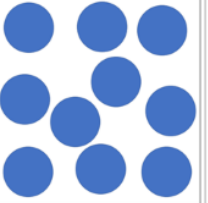
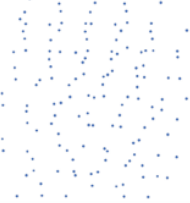
	10 μm (Coarse)	2.5 μm (Fine)	0.1 μm (Ultrafine)
			
Total mass	1	1	1
Particle number	1	64	1,000,000
Surface area per particle	1	0.0625	0.0001
Total surface area per mass	1	4	100
	<ul style="list-style-type: none"> • Filtered in proximal airway • May irritate skin, mucosa 	<ul style="list-style-type: none"> • Reaches peripheral airway • Cannot enter systemic circulation 	<ul style="list-style-type: none"> • Higher adsorbed toxic material on surface • May enter systemic circulation

Figure 2 - Relative sizes of small particles [34]

The size of generated particles impacts the time that it takes for those particles to settle or “drop” out of the air. For example, it may take approximately 13 minutes for a 10µm (micron) coarse particle to settle (in still air), that extends to 19 hours for a 1µm particle and approximately 79 days for a 0.1µm ultrafine particle. [35]

Particle size also influences toxicity. A recent experimental study reported that in addition to the high concentrations of particles <1µm emitted during processing, dust emissions from engineered stone had both larger surface areas and generally higher surface charge in comparison to dust from natural stone. [19] The presence of particles <1µm, including ultrafines is important. These can more easily enter the body and have been associated with effects beyond the respiratory system such as autoimmune disease. [36] The increased surface area and charge are also important factors relating to toxicity. [19] The types of tools used during fabrication and the quality of water (e.g. recycled water) used for dust suppression also influences the composition of the dust, as does the presence of a range of metals including iron, zirconium, titanium and aluminium in the parent stone. [37]

The amount of RCS in the air (as an airborne concentration) depends on a number of factors, such as the kind of abrasive surface, pressure applied to the tool, type of tool, rotational speed, the contact surface area etc. The UK HSE [31] and US NIOSH [12] have attempted to control as many variables as possible in order to compare the emissions under “standard” conditions. However, there appears to be no standard which would lead to a comparative measure under the varied abrasive conditions for working engineered stone.

“Dustiness” is the term used to describe the propensity to form airborne dust by a prescribed mechanical stimulus [38]. While a European Standard exists for the assessment of dustiness related to workplace conditions [39] it doesn’t specify a method to assess dust generated by abrasion. There are methods for evaluating the emissions from machinery which may be modified for this purpose. [40] [41]

It has been reported that for many minerals with increasing grain size, the dustiness initially increases and then decreases. For example, the dustiness of quartz and cristobalite increases for samples with d_{50} (the median particle diameter by volume) up to about 150µm and then suddenly decreases in coarser mineral product grades. However, feldspar displays a similar dustiness regardless of the grain size of the material. It can be inferred that RCS displays unusual dustiness characteristics based on particle size. This may be related to its electrical properties and may have implications for workers in close proximity to the source of dust generation. [42]

This is important, because the standard approach for measuring occupational exposure to RCS is by weight (not particle number). The high number of ultrafine particles

generated from processing engineered stone would result in a negligible weight difference as measured during occupational exposure monitoring but a very large number of particles. This increase in ultrafine particles supports a precautionary approach to dust from engineered stone.

Silica is not only quartz

The crystalline silica in most engineered stones is in the form of quartz, but there are other polymorphs (or types) of crystalline silica of significant concern, one being cristobalite. Quartz and cristobalite are recognised as Group 1 carcinogens "*carcinogenic to humans*" by the International Agency for Research on Cancer [43]

Some types of engineered stone may contain both quartz and cristobalite. [44] Cristobalite is dominant in volcanic rocks as it is formed at high temperatures. It is ubiquitous in the subsurface in Spain and the Spanish government has set an exposure standard for cristobalite of 0.05 mg/m³, half of that of quartz, of 0.1 mg/m³. [45] At present, Australia has the same WES for cristobalite and quartz. Occupational exposure to cristobalite in Australia has been comparatively rare with the exception from high-temperature processes where cristobalite can be created such as in ceramics and foundries.

In Australia, analysis of respirable dust on filters for RCS is performed either by Fourier transform infrared spectroscopy (FTIR) or X-ray diffraction (XRD). Cristobalite can interfere with FTIR analysis. [46] If both quartz and appreciable levels of cristobalite are present in the sample, then sampling and analysis should be undertaken for both types of RCS using standardised analytical techniques.

We highlight this as a critical issue, to support the need for all air monitoring for RCS to be undertaken under the governance of a Certified Occupational Hygienist (COH)[®] to account for the complexities of the analyses, which might under or overestimate exposure estimations. We are concerned that the costs of analysis might deter employers from carrying out accurate air monitoring if the importation of engineered stone containing appreciable concentrations of cristobalite continue.

Amorphous Silica

Amorphous silica is a form of silicon dioxide that does not have a crystalline structure. Instead, it exists in a disordered or random arrangement of atoms and molecules, which gives it its name "*amorphous*" meaning without a defined shape. Amorphous silica is found in various forms, including powder, gel, or glassy solids. One of the unique properties of amorphous silica is its high surface area, which makes it useful as a catalyst and adsorbent. It also has high thermal stability and resistance to chemical

reactions, making it a valuable material in many industrial processes. In the context of engineered stone, the most common source of amorphous silica is from recycled glass.

The various forms of amorphous silica are widely thought to be less toxic than crystalline silica. [47] [48] However pulmonary fibrosis has been observed in animals exposed to amorphous silica. [48] The inhalation of amorphous silica is known to induce pulmonary toxicity, including pulmonary inflammation, granuloma formation, increased cellular infiltrates, and reduced lung function. Pulmonary effects observed following exposure to amorphous silica are generally reversible and no progressive fibrosis is observed. [48] Australia has set WESs for amorphous silica, however they only apply in circumstances where the concentration of crystalline silica is below 1%.

Significant exposures to amorphous silica can occur from processing engineered stone containing recycled glass. A study comparing the amount and type of dust generated by grinding different types of engineered stone, one of which contained recycled glass showed that the number-weighted particle size distributions were the highest for the recycled glass stone. [12] This means that the number of particles being generated from stone containing glass were higher in comparison to that from other stone types, which is cause for application of the precautionary principle.

It has long been known that freshly fractured quartz is more biologically active than weathered quartz [49] e.g., beach sand. This raises concerns that exposure to freshly ground amorphous silica from processing engineered stone containing recycled glass, may also be biologically active when inhaled. Studies into the toxicity of freshly made dust from quartz and amorphous silica found that both *"show irregular particles with sharp edges, stable surface radicals, and sustained release of HO(*) radicals via a Fenton-like mechanism"* and that amorphous silica behaves like quartz dust. [50, 51]

Amorphous silica particles show the same micromorphology (irregular surfaces and pointed edges) and reactivity of quartz in acellular and cellular tests and it has the potential to generate free radicals in simulated biological fluid, haemolytic activity, and cytotoxic and proinflammatory activity in alveolar macrophages. The literature also reports that silanols form on the surface of freshly fractured amorphous silica particles. Silanols can damage cell membranes and result in an inflammatory lung reaction. [52, 53] This is significant as these are the same processes that cause quartz to have its toxic effect. Internationally, NIOSH in the USA have recognised the need for more studies to determine the overall health effects from the corresponding dust. [12]

Significantly, several cases of silicosis and lung cancer have been reported in the past among workers who use quartz as the primary raw material but are mostly exposed to amorphous silica particles in glass factories. [51]

Further information is needed to quantify the toxicity of dust generated by processing engineered stone containing amorphous silica such as recycled glass. Based on the precautionary principle, the dust from such stone should be regarded as hazardous until data exonerating it are available.

Other constituents in the product

The type of emissions from engineered stone are qualitatively different from granite, as there are pigments, metals and organic resins not found in natural stone. A number of papers have argued that these components may contribute to the type of accelerated silicosis seen in workers exposed to respirable engineered stone dust [5] [54]. Concerns have been raised in relation to the presence of VOC's, PAH's and metals, as they are known to cause respiratory disease and lung inflammation on their own.

Engineered stone, unlike natural stones, contains organic resins as binding agents. These resins may form a protective coating over freshly produced silica particles increasing their toxicity and have also been described in association with other occupational lung diseases including asthma and hypersensitivity pneumonitis [37]. Engineered stone is anticipated to contain many chemicals of special concern, [55] some of which are the subject of current research.

The potential independent and synergistic effects of non-crystalline silica constituents are important additional considerations when determining a percentage of crystalline silica in the bulk material that may be acceptable. The current approximate 20% by volume component of organic resin, which cannot be considered as completely inert, becomes a lung-embedded microplastic particle, which has not been investigated so far.

The scientific literature supports the view that the most effective course of action is the elimination of the hazard of crystalline silica through a change in material composition. [5]

Given the additional toxicological considerations of non-crystalline silica constituents, a threshold of less than that calculated on silica acceptability alone is prudent. We therefore recommend that consideration be applied to the future development of a WES for respirable engineered stone dust. In addition to the need to account for 'other constituents', the application of the WES for amorphous silica relies on the respirable dust to contain less than 1% crystalline silica, which is likely not the case in the majority of circumstances.

Product Stewardship

Product stewardship is the concept that suppliers of a product are responsible for its impacts from formulation, manufacture, use, storage, transport and disposal in all foreseeable circumstances. Engineered stone is a formulated synthetic product. While manufacturers hold the knowledge on product formulation, little knowledge is available on the toxicology of the process generated substances.

The current legislative framework requires labelling and the provision of SDSs for hazardous substances introduced into the workplace. Engineered stone has been defined as an “article” which is “a *manufactured item, other than a fluid or particle, that is formed into a particular shape or design during manufacture and has hazard properties and a function that are wholly or partly dependent on the shape or design.*”

The historical absence of information (such as SDS and labelling) for workers on the potential hazards of engineered stone products was cited by the Department of Health [56] and can be linked back to its classification as an article.

The classification packaging and labelling requirements for SDSs fall under Schedule 9 of the Model WHS Regulations. For engineered stone, it is dust, the waste product from processing that is harmful and so engineered stone does not require an SDS;

“Designers, manufacturers, importers and suppliers do not have a duty to provide this information as a safety data sheet for solid products that contain crystalline silica, such as engineered stone. However, safety data sheets are an effective way to communicate information downstream about the risks when working with engineered stone. It is considered good practice to make them available.” [57]

It is the responsibility of employer to determine whether any hazardous substances are generated from a material being processed (s351 of the model WHS Regulations). In the case of engineered stone, substances created from resin components are not identified in any SDS and have only been recently identified by university research. [58] It is unreasonable to expect an employer operating a small business to identify substances which are not listed in the SDS.

The AIOH has previously recommended that chemicals created as a by-product during a work process, so called “*process-generated substances / carcinogens*” be given a higher visibility and clearer status. As these are usually not considered under existing Globally Harmonised System of Classification (GHS) chemical management, they are therefore not labelled and not referred to in SDSs, but they do need special attention in practice.

In the European Union, a special project is underway by national organisations targeting process-generated carcinogens (PGCs) of which silica is the most prevalent¹.

The responsibility for accurate reporting of product constituents should rest with the manufacturer, supplier or importer of the products. SDS are the principal tool of hazard communication and are supposed to meet the obligations of a PCBU in regard to the worker “*right to know*” principle. Employers and workers have a right to know about the hazards and risks associated with the products that they handle and work with, including those reasonably expected to be generated when the product is processed. At present, GHS labelling is heavily biased towards chemicals and chemical mixtures and allows the hazardous dust emissions from silica to go undeclared. As a result, few engineered stone SDSs carry the Hazard Statement H350i “*May cause cancer by inhalation*” which is required of asbestos containing materials and generally receives good compliance.

In addition, the GHS hazard classification STOT-RE could be used to alert users to other respiratory diseases. However, under these global SDS provisions, engineered stone importers can avoid declaring pneumoconiosis, pulmonary fibrosis, silicosis, lung cancer, chronic obstructive pulmonary disease (COPD) and other diseases associated with RCS exposure, even though RCS is an unavoidable by-product of engineered stone processing.

To address this shortcoming, we recommend that policy makers impose product stewardship requirements for engineered stone importers (or manufacturers) that include mandatory standardised test methods to include greater accuracy and information on the toxicological impacts of processing their materials.

We also suggest that the current guidance, laws and structures used to support the prohibition of asbestos into Australia be examined for potential extension.

Compliance Practices

Many jurisdictional regulators have reported on compliance practices in engineered stone workplaces previously. [30, 59] To best inform what type of intervention was needed to prevent the silicosis epidemic, the AIOH commissioned a study of our members experiences who are on the frontlines in Australian workplaces. [24]

That study demonstrated that in 2021, more than 7 out of 10 occupational hygienists were concerned about the potential for over-exposure to RCS. Concerningly, the majority of respondents were concerned that some of the exposures exceeded the WES

¹ <https://roadmaponcarcinogens.eu>

and that there was potential for higher exposures. The most common barriers to adequate prevention by employers were reported to be “a *lack of management commitment and financial resources*”.

The issue of poor compliance with safety standards is not isolated to Australia. In New Zealand, WorkSafe New Zealand reported that 93% of the 126 engineered stone businesses that received an inspection between 2019 and 1 November 2022 received a compliance notice².

The general low-level of compliance with work health and safety legislative requirements in this sector further supports a precautionary approach to this issue.

Precautionary Principle

The precautionary principle is a guiding principle in decision-making that recommends that in situations where there is a potential risk of harm to health, precautionary measures should be taken even if the scientific evidence is uncertain or incomplete. This principle is enshrined in Commonwealth environmental law [60] and applied variously across the nation in public health policy and legislation. [61] [62] [63]

In the context of decisions around a percentage of crystalline silica in engineered stone that is viewed as “*acceptable*”, the precautionary principle would suggest that measures should be taken to protect workers from exposure to dusts generated from processing engineered stone, even if the full extent of the risk is not yet completely understood. We anticipate Safe Work Australia would adopt these principles in making a final decision regarding engineered stone, in preference to a cut-off level which cannot yet be shown to be protective of irreversible health effects.

Summary

There are many examples of using the proportion of a hazardous substance in a material to decide if higher health and safety standards are necessary, the lead regulations being one example. However, determining the level of risk from engineered stone is more complex. Risk factors such as the amount, particle size and charge of the dust particles created during processing in addition to the potential independent and synergistic toxic effects of non-crystalline silica constituents present in engineered stone must all be considered.

There is insufficient evidence to arrive at a discrete percentage of crystalline silica in the stone slab to underpin a specific cut-off for prohibition purposes, based on what is

² WorkSafe New Zealand, personal communication

protective of worker health, or indeed “safe”. The 40% crystalline silica value used in Victorian regulation cannot be considered a safe level according to the weight of evidence we have compiled.

Silica toxicity is not the only safety consideration in handling engineered stone. The current approximate 20% by volume component of organic resin cannot be considered as completely inert. This significant constituent of engineered stone is effectively a lung-embedded microplastic issue, which has not been investigated so far.

There are engineered stone products on the market with 10% or less crystalline silica, and there is evidence that the emissions from processing low silica products have correspondingly low RCS concentrations. A value of 10% crystalline silica is evidently manageable by industry. We recommend that processing engineered stone containing more than 10% crystalline silica should be prohibited. This is on the basis of the practicality criterion, observed high emissions and the hierarchy of hazard control (section 36 of the Model WHS regulations), given the *prima facie* evidence of silicosis including accelerated silicosis developing in engineered stone workers.

However, a concentration of 10% crystalline silica is not without risk and so commits workplaces to a high degree of regulation and employers and workers to implement effective engineering controls to avoid a high reliance on respiratory protection.

Therefore, the AIOH is supportive of a prohibition on the use of engineered stone, including a prohibition on the use of all engineered stone irrespective of its crystalline silica content.

We acknowledge that choosing a specific percentage of crystalline silica as a cut off for the prohibition of engineered stone will likely lead to modified or new engineered stone products reaching the Australian market. It is paramount that policy makers anticipate and consider potential “new” health hazards that may arise from these products that may lead to occupational disease in workers or second generation users (e.g. home renovators, polishing stone etc).

We recommend that consideration be applied to the future development of a WES for respirable engineered stone dust. This approach would be similar to the one taken for wood dust, and would ensure that all constituents of the complex mixtures of engineered stone, such as various forms of crystalline silica, amorphous silica, pigments, and resins bound to particulates, are covered.

We also recognise that, just like with asbestos, if the importation of engineered stone is prohibited, there will be a need to establish procedures for exemptions, such as for research applications.

Answers to Questions

Q1. Do you support a prohibition on the use of engineered stone? Please support your response with reasons and evidence.

Yes. Evidence is provided in earlier sections of this document.

Q2. If yes, do you support a prohibition on the use of all engineered stone irrespective of its crystalline silica content? Please support your response with reasons and evidence.

We submit that there is insufficient evidence to arrive at a discrete percentage of crystalline silica in the stone slab to underpin a specific cut-off for prohibition purposes, based on what is protective of worker health, or indeed “safe”.

Q3. If no, do you support a prohibition of engineered stone that contains more than certain percentage of crystalline silica? If yes, at what percentage of crystalline silica should a prohibition be set? Please support your response with reasons and evidence.

A value of 10% crystalline silica in engineered stone is evidently manageable by industry and incorporates a commonly accepted toxicological margin of safety for non-cancer endpoints. If processing engineered stone containing more than 10% crystalline silica is prohibited, a high degree of regulation is required as a complimentary measure.

Q6. Do you have any data or information on the risks to workers from the other non-crystalline silica elements of engineered stone? Are these risks increased in engineered stone of less than 40% crystalline silica content?

Yes. Non-crystalline silica elements of engineered stone of concern include:

- Amorphous silica
- Resin
- Volatile organic compounds
- Pigments
- Metals

The non-crystalline silica elements within engineered stone cannot be considered as completely inert. As the weight of crystalline silica in engineered stone decreases, the non-crystalline silica component will increase. Little information on the toxicology of such constituents exists at present.

Q7. In relation to Option 3, do you have:

- any information on the additional benefits of a licensing scheme over the enhanced regulation agreed by WHS ministers (Option 5a) that would already apply to engineered stone products containing less than 40% crystalline silica content?
- feedback on the implementation of concurrent licensing schemes for both prohibited engineered stone and non-prohibited engineered stone?

We respectfully leave the feedback to the implementation of current licensing schemes to the Regulators to comment.

We raise concern that if licencing or regulation refers to a percentage of silica in a product, that it is explicit if that percentage is on a weight or a volume basis. At present, SDSs report the percentage on a weight basis. As the density of 'other' non-crystalline silica components is less than 1, we caution the possibility of suppliers changing their SDSs to report on a volume basis, thereby artificially lowering the proportion of silica simply by using alternative measures of reporting.

We also raise concern on the current definition of engineered stone in cases where crystalline silica is absent. Uncontrolled dry processing of engineered stone containing amorphous silica and other potentially toxic constituents (resin, volatile organic compounds, polycyclic aromatic hydrocarbons, and metals) is anticipated to pose a significant risk to health. We therefore recommend a licencing scheme be implemented for all engineered stone products, regardless of crystalline silica content.

A licensing scheme alone doesn't close the gap to declare the toxic constituents generated from processing engineered stone. Processes must be enacted to ensure that suppliers are required to provide a full declaration of emissions from engineered stone coming into Australia.

Abbreviations

Abbreviation	Definition
AIOH	Australian Institute of Occupational Hygienists Inc.
COPD	Chronic obstructive pulmonary disease
FTIR	Fourier transform infrared spectroscopy
GHS	Globally Harmonised System of Classification
mg/m ³	milligrams per cubic metre
PAH	Polycyclic Aromatic Hydrocarbons
PGC	Process-generated carcinogens
RCS	Respirable crystalline silica
RPE	Respiratory protective equipment
SDS	Safety data sheet
TWA	Time weighted average
µm	Micron (1 millionth of a metre)
VOC	Volatile organic compounds
WES	Workplace exposure standard
WHS	Work health and safety
XRD	X-ray diffractometry

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