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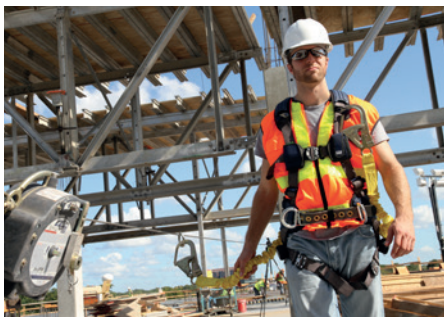
Respirable crystalline silica – hazards and exposures.

Introduction

Respirable crystalline silica is a dangerous workplace hazard, and over the millennia has killed thousands of workers. Respiratory illnesses associated with masonry and stone working industries were recognised hundreds of years ago[1, 2], but it wasn't until the 1930s that the risks from silica were recognised in many different industries and processes[3]. Despite this, crystalline silica still presents a particular risk to workers in the construction industry today, as new materials, construction techniques and equipment change how the world is built.



Silica

Silica or silicon dioxide (SiO_2) is one of the most common naturally occurring minerals on the planet. Furthermore, forms of silica are specifically manufactured by industry for their unique chemical (generally inert), physical (strong but brittle material with relatively high melting point) and electrical properties. The intra-molecular polar covalent bonds results in tetrahedral ordered molecular structures, which can be grouped as follows:

Amorphous silica

Molecules are arranged with limited ordering relative to each other, resulting in a transparent solid. Occurring rarely in nature, amorphous silica is extensively used within industry – particularly as the main component in glass and more latterly in the electronics industry[4].

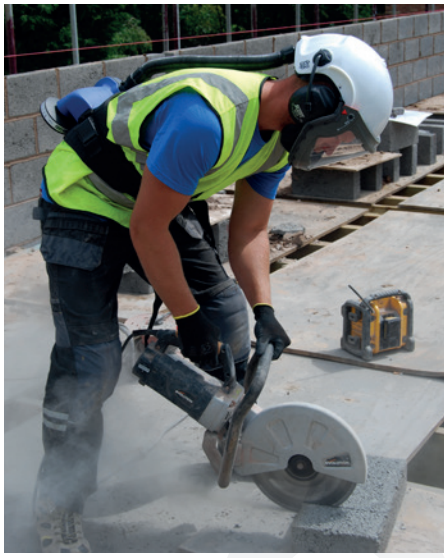
Crystalline silica

Molecules are arranged with indefinite ordering relative to each other, resulting in distinct crystalline structures that are white or yellowish in appearance. Nine different crystalline structural forms (polymorphs) exist – the most common forms of which are quartz, followed by cristobalite and tridymite. Crystalline silica is a key component of soil, sand, granite and other naturally occurring minerals[4].

Respirable crystalline silica (RCS)

RCS is commonly used to refer to the tiny particles (at least 100 times smaller than ordinary grains of sand) of crystalline silica that are too small to be seen by the human eye. They can remain in the air for extended periods of time and inhaled deeply into the lungs. These particles are created when handling, using, cutting, sanding or carving materials containing crystalline silica[5, 6].

According to the UK Health and Safety Executive (HSE), due to its presence in commonly used construction materials (see Table 2), RCS is the second biggest health risk to construction workers, following asbestos[7]. The HSE estimates that excessive exposure to silica was responsible for between 10 and 20 deaths annually over the last 10 years[8].

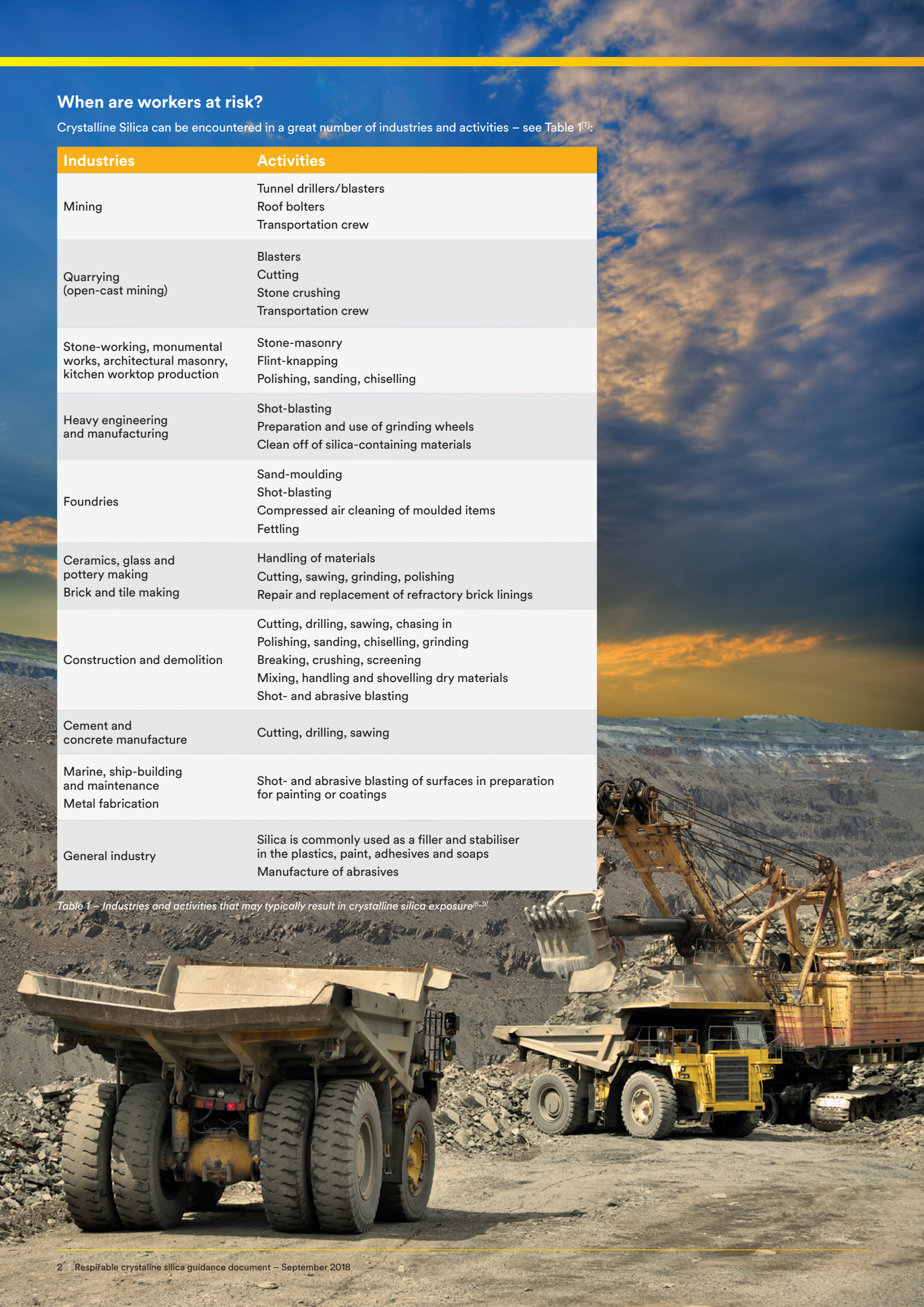


When are workers at risk?

Crystalline Silica can be encountered in a great number of industries and activities – see Table 1[7]:

Industries	Activities
Mining	Tunnel drillers/blasters Roof bolters Transportation crew
Quarrying (open-cast mining)	Blasters Cutting Stone crushing Transportation crew
Stone-working, monumental works, architectural masonry, kitchen worktop production	Stone-masonry Flint-knapping Polishing, sanding, chiselling
Heavy engineering and manufacturing	Shot-blasting Preparation and use of grinding wheels Clean off of silica-containing materials
Foundries	Sand-moulding Shot-blasting Compressed air cleaning of moulded items Fettling
Ceramics, glass and pottery making Brick and tile making	Handling of materials Cutting, sawing, grinding, polishing Repair and replacement of refractory brick linings
Construction and demolition	Cutting, drilling, sawing, chasing in Polishing, sanding, chiselling, grinding Breaking, crushing, screening Mixing, handling and shovelling dry materials Shot- and abrasive blasting
Cement and concrete manufacture	Cutting, drilling, sawing
Marine, ship-building and maintenance Metal fabrication	Shot- and abrasive blasting of surfaces in preparation for painting or coatings
General industry	Silica is commonly used as a filler and stabiliser in the plastics, paint, adhesives and soaps Manufacture of abrasives

Table 1 – Industries and activities that may typically result in crystalline silica exposure[6–9]



Respirable crystalline silica and the construction industry

As can be seen on the previous page, the construction industry commonly uses materials that contain high proportions of crystalline silica. Contact with these materials occurs during many different construction operations. Most exposures occur during abrasive blasting with sand to remove paint from concrete structures and other surfaces. Other construction operations that may possibly result in exposure include: using pneumatic drills, rock drilling, concrete mixing, concrete drilling, brick and block cutting and sawing, as well as tunnelling operations.

Material	Approximate crystalline silica content
Sandstone	70-90%
Concrete, mortar	25-70%
Tile	30-45%
Granite	20-45%, typically 30%
Slate	20-40%
Brick	< 30%
Limestone	2%
Marble	2%

Table 2 – Crystalline silica content in common construction materials[6]

What are the risks from repeated, excessive exposure to silica dust?

Awareness of the dangers posed by breathing RCS is increasing, but still many workers do not fully understand health risks of RCS exposure. Respirable crystalline silica can cause irreversible fibro cardiovascular diseases such as[6, 9]:

- Silicosis
- Lung cancer
- Chronic obstructive pulmonary disease (COPD)
- Bronchitis and emphysema
- Other effects including autoimmune, immunological and renal diseases have been reported. In addition, there is strong link between RCS exposure, silicosis and an increased risk of tuberculosis

Silicosis

Silicosis is a form of pneumoconiosis, with typically a long latency period between initial exposure and onset of disease symptoms. Crystalline silica particles enter the lung, over-load the body's defence mechanisms and cause irritation and damage to the alveoli. The body reacts by forming fibrous tissue around the trapped silica particles, and scarring of the lungs develops. Over time, as the extent of scarring continues, the efficiency of the lungs decreases, and symptoms of silicosis develop. Unfortunately, no specific intervention is known to halt the progression of silicosis – silicosis is incurable and can lead to significant ill health and even death.

There are 3 types of silicosis[10]**:**

1. **Acute silicosis**: The individual will have been typically exposed to very high levels of silica dust and symptoms will result in a matter of weeks or months.
2. **Accelerated silicosis**: A gradual onset of shortness of breath and dry cough occurs many years after exposure to medium to high levels exposure to RCS.
3. **Chronic silicosis**: This is the most common type and usually occurs after >10 years' exposure to low level silica dust.

Symptoms of silicosis

Symptoms of silicosis can take many years to develop. It is important that workers are aware of what these are so they know what to look out for[11]:

- Debilitating shortness of breath
- Loud cough
- Feeling of weakness
- Weight loss
- Chest pains
- Night sweats

Minimising exposure to respirable crystalline silica

There are many ways of minimising personal exposures, but one of the most important ways is to use established occupational hygiene best practises that comply with all national regulations and laws. These activities typically involve the following key elements[6, 12], but the appropriateness of each may vary by industry and application[13]:

1. Identification of the hazards and assessment of the risks.
2. Implementation of appropriate controls to minimise worker exposures.
    a. **Elimination:** can materials be sourced that do not need to be cut or finished?
    b. **Substitution:** can alternative materials that do not contain crystalline silica be used or can alternative process be used that generates less of a hazard?
    c. **Engineering controls:** can controls such as local exhaust ventilation, on tool extraction, water suppression, enclosures or vacuum cleaning be used to reduce exposures?
    d. **Administrative controls:** can high risk activities be conducted away from other workers?
    e. **Use of PPE:** select and use appropriate and suitable respiratory protective devices when the other controls do not adequately control exposures.
3. Education and training of workers around the effects of silica dust exposures, best practises and control measures.
4. Ongoing review of the risks and effectiveness of the controls.

Use of appropriate PPE

Although this document focusses on the respiratory hazards and risks, there will likely be many health and safety risks in the workplace and a combination of control measures, including a range of Personal Protective Equipment, will likely be required. Recommendations and regulations vary by country, so always check your national regulations.

3M offers a range of disposable, reusable, half-face, full-face respirators, in addition to powered and supplied breathable air respirators, as well as airline and self-contained breathing apparatus that may be appropriate for use – depending upon the level of respiratory protection identified by the employer's risk assessment, national guidance and suitability for the task.

References

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