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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<sup>[1, 2]</sup>, but it wasn't until the 1930s that the risks from silica were recognised in many different industries and processes<sup>[3]</sup>. 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<sup>[4]</sup>.

#### **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<sup>[4]</sup>.

#### 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<sup>(5, 6)</sup>.

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<sup>[7]</sup>. The HSE estimates that excessive exposure to silica was responsible for between 10 and 20 deaths annually over the last 10 years<sup>[8]</sup>.



# When are workers at risk?

Crystalline Silica can be encountered in a great number of industries and activities - see Table 17:

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

Table 1 – Industries and activities that may typically result in crystalline silica exposu

### 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%
Marble	2%

Table 2 – Crystalline silica content in common construction materials<sup>[6]</sup>

# 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<sup>[6, 9]</sup>:

- 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<sup>[10]</sup>:

- 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.
- 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.
- 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<sup>[11]</sup>:

- 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<sup>[6, 12]</sup>, but the appropriateness of each may vary by industry and application<sup>[13]</sup>:

- 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.
- 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.

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# Beyond the cutting and grinding.

Helping to reduce your exposure to respirable crystalline silica.

Every time you set foot on a new construction site, into the foundry or quarry, you take stock of the different risks and dangers to avoid. You spot small pieces of concrete flying into the air as your co-worker uses a pneumatic drill to break up a piece of pavement. You notice the dust as the rock and stone are drilled and cut. But what about the dangers you can't see? The tiny silica particles from the pavement and stone block that enter your respiratory system and potentially your lungs?



Figure 1 – Crystalline silica content in commonly used construction materials



Figure 2 - Construction activities that may create respirable crystalline silica

# What is crystalline silica?

Crystalline silica (silicon dioxide,  $SiO_2$ ) is one of the most common naturally occurring minerals on the earth. In the form of quartz, it is a basic component of many soils, sands and rocks<sup>[1]</sup>, which are in turn used in products like concrete, brick, ceramic tiles, dental filings, jewellery, tombstones and more<sup>[2]</sup>.

#### How could it affect me?

When respirable crystalline silica particles are inhaled, they can make their way deep into your lungs. When that happens, the silica particles then cause scar tissue nodules to develop in the lungs<sup>[2]</sup>. While it may take years to develop, this is the disease silicosis. Silicosis is a non-reversible lung disease with symptoms that can range from shortness of breath and chest pains to increased difficulty in breathing. It may eventually also be fatal. Exposure to respirable crystalline silica has also been recently associated with other lung diseases.

# When am I at risk?

Crystalline silica is more likely to be present in the air when there is cutting, sawing, drilling or crushing of concrete, brick, ceramic tiles, rocks or stones, but also when handling sand and powdered silica. Examples of potential workplaces with these types of activities might include foundries, mines, and sites that use abrasive blasting<sup>[3]</sup>.

Workers in the construction industry are particularly at risk of exposure to respirable crystalline silica due to the high content in common construction materials and the types of activities undertaken on construction sites<sup>[3]</sup> – see Figure 1 and Figure 2.



#### What can I do to protect my workers?

No matter where you work, it is essential to understand the different products and processes being used around your workplace, to help determine the appropriate controls (engineering and administrative), as well as protective gear, to reduce the potential risk.

#### Use appropriate controls

There are a few different ways of controlling dust levels in your workplace, which will help keep silica particles from becoming airborne. Controls should start with trying to eliminate the hazard, for example sourcing cut-to-size materials, or substitution of high quartz content materials to low (or no) quartz content alternatives. Many worksites will also opt for engineering controls like wet cutting, vacuum dust collection systems, or water misting of work sites to keep silica dust from becoming airborne. Administrative controls such as restricting access to controlled work areas, as well as adequate training should be used wherever possible. Finally, the use of PPE including respiratory protective devices when other controls do not adequately control exposures<sup>[4]</sup>.

#### Stay informed

Certain countries and regions have different rules and regulations around managing silica exposure so it's important to stay up to date on legal requirements and testing to help minimise risk.

#### Get the equipment that you need

Respiratory, ocular, hearing, head protective equipment, among others, is likely needed when cutting, sawing, drilling or crushing silica containing materials or conducting other activities that may result in exposure. Recommendations and regulations vary by country, so always check your national regulations.

Once you have a sense of the hazards and risks in your workplace, you'll want to take a look at 3M's full range of respiratory protection products, safety eyewear and coveralls to find the right PPE for your application. Whether it be a half-face respirator, full-face mask and filters or a heavy duty powered or supplied air helmet; all our products are designed to help you get the job done while you breathe comfortably and safely.

At any time, you can get in touch with one of our respiratory experts for personalised help on the selection and use of 3M products. Their job is help you through the process of selecting adequate and suitable products based upon your risk assessment, helping you keep your lungs safe so you can focus on what matters: doing your job properly and staying healthy for your loved ones and family.





In 2014/15, within the UK construction industry<sup>[5]</sup>:

- 35 workers sustained fatal injuries
- 5,500 workers were diagnosed with new cases of occupational cancer
- 3,500 workers died due to past exposure to asbestos
- 500 workers died due to past exposure to silica

#### Did you know?

- In the UK, the Workplace Exposure Limit<sup>[6]</sup> for Respirable Crystalline Silica is 0.1mg/m<sup>3</sup> TWA
- 0.1mg RCS is illustrated below in Figure 3<sup>[7]</sup>; this represents a typical maximum daily permitted dose in the UK



Figure 3 – Illustration of 0.1mg of respirable crystalline silica<sup>[7]</sup>

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## Find out more

hse.gov.uk/construction/healthrisks/ cancer-and-construction/silica-dust.htm

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