Occupational Health and Safety Bulletin

WORK SAFE ALBERTA

Crystalline Silica at the Work Site

Silica is the scientific name for a group of minerals made of silicon and oxygen. Silica is found in most mineral deposits in the world in both crystalline and non-crystalline (amorphous) forms. Crystalline silica has its oxygen and silicon atoms arranged in a three-dimensional repeating pattern. Amorphous forms of silica have a random pattern. Crystalline silica occurs in several forms, including quartz, cristobalite and tridymite. Quartz is the most common form of crystalline silica. It is the crystalline form of silica that is the main concern when considering health effects.

Silica is the scientific name for a group of minerals made of silicon and oxygen.

Silica's many uses include:

- molds and cores used to make metal castings
- refractory brick used in foundries, power plants and cement plants
- filter media for water filtration systems
- sports and recreational uses such as sand traps on golf courses and sand in playgrounds
- sandblasting abrasives
- building materials such as concrete, grout and plaster
- glass and fibreglass
- ceramics and fine china
- plastics and paints
- dental materials
- components for electronics, fibre-optics, lasers, and time keeping devices
- proppant for hydraulic fracturing in oilfield applications.

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Alberta Government

Silica dust is produced during construction-related activities such as bricklaying, stone setting and demolition, and repair of concrete materials. It is also produced during rock drilling, dry sweeping, abrasive blasting, quarrying and mining.

When some silicon-containing materials are exposed to heat, they form crystalline silica. The crystalline silica is often more hazardous to workers than the original material. For example, cristobalite can form when refractory ceramic fibre insulation is exposed to temperatures of 1100 to 1300^{O}C (the higher the temperature, the less time it takes for cristabolite to form), or when some forms of amorphous silica such as diatomaceous earth are exposed to temperatures greater than 800^{O}C.

Health effects

Exposure to crystalline silica can cause a number of health problems.

Crystalline silica dust particles that are small enough to be inhaled into the lungs can cause a number of health problems, including silicosis, lung cancer, chronic obstructive pulmonary disease and emphysema, as well as pulmonary tuberculosis.

Silicosis

Silicosis is caused when crystalline silica particles less than 10 microns in diameter are inhaled and deposited in the lungs. This is known as “respirable” silica. Lung tissue reacts by developing lumps and scarring around the trapped silica particles. If the lumps and scar tissue grow too large, breathing becomes difficult and death may result.

Factors that influence the development of silicosis include:

- particle type e.g. quartz
- particle size — particles larger than 10 microns in diameter tend to be deposited in the nose or throat rather than the lungs
- how long a person is exposed to silica dust
- the concentration of silica dust in the air
- individual susceptibility.

Silicosis can develop or progress even though exposure to crystalline silica has stopped. Three types of silicosis can develop:

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(1) *chronic silicosis* — may develop due to ongoing (chronic) exposure to relatively low concentrations over a long period of time i.e. ten or more years.

(2) *accelerated silicosis* — may develop five to ten years after the first exposure to high concentrations.

(3) *acute silicosis* — may develop after exposure to very high concentrations of respirable silica. Symptoms appear within a few weeks to five years of the initial exposure. This disease is usually associated with a history of repeated exposures to tasks that produce small particles of airborne dust with a high silica content e.g. sandblasting, rock drilling or quartz milling.

Workers with silicosis may at first have no symptoms. As the disease progresses, coughing develops and breathing becomes difficult. Persons with silicosis have an increased risk of contracting respiratory infections such as pneumonia and tuberculosis. This happens when lung cells that normally kill infectious organisms are overwhelmed by silica dust and are unable to do their job.

Lung Cancer

In 1996, the International Agency for Research on Cancer (IARC) concluded that there was enough scientific evidence to suggest that occupational exposure to respirable quartz and cristobalite can cause cancer. Quartz and cristobalite are classified as “Group 1, carcinogenic to humans”. Workers exposed to high concentrations of respirable dust who have developed silicosis have an increased risk of developing lung cancer.

Other health problems

Some research suggests that there is an association between workers exposed to respirable crystalline silica with rheumatoid arthritis and abnormal kidney function.

Health assessment

Since there is no cure for silicosis, early detection is very important. Exposure must be minimized or eliminated if health effects are discovered. The silica-exposed worker should undergo a health assessment to provide a baseline health evaluation so that early changes to the lungs can be more easily detected.

A health assessment for silica-exposed workers consists of health history information, a chest x-ray, a radiologist's report, a lung function test and a physician's written interpretation and explanation of the assessment results.

The history includes identifying the worker, the employer, the worker's previous work and non-work exposure to crystalline silica or other dusts, indications of any existing respiratory disease, smoking history and the date on which the worker had his or her most recent chest x-ray or lung function test.

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The chest x-ray consists of a single back to front (postero-anterior) view of the chest. The x-ray must be interpreted by a radiologist and the resulting report sent to a physician. Digital imaging format of x-rays is being used by some radiologists. Digital imaging can be used to meet the requirements in the Occupational Health and Safety (OHS) Code provided the imaging facility is able to print to film whtn requested.

The lung function test, also called pulmonary function test, is done by a pulmonary function technician and involves measuring the volume capacity of lungs and the rate of air flow out of the lungs.

The employer is responsible for ensuring that an exposed worker has a health assessment at no cost to the worker. A health assessment must be done within 30 days of a worker becoming an exposed worker (as defined in the legislation) and must be done every two years thereafter. Information in the health assessment is confidential and persons having custody of the information must ensure that it is kept confidential.

Protecting your health

Preventing exposure to crystalline silica is the best way to protect health. Options that should be considered include the following (listed in order of preference):

- using less hazardous substitutes
- using engineering controls
- changing work practices to reduce exposure (administrative controls)
- using personal protective equipment.

Silica substitutes in abrasive blasting

For many products that use silica as an ingredient, there are no substitute materials. However, a wide variety of materials can, where practical, be used as substitutes to silica in abrasive blasting. A number of factors need to be considered when looking at substitutes. These include the hardness of the material, cost, coverage, and health effects.

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Materials that can be used as a substitute for silica in abrasive blasting include:

- *aluminum oxide (artificial corundum)* — this product is made by fusing calcined abrasive bauxite in a furnace. Compared to silica sand, the material is harder and tends to cause more wear on blast nozzles and other equipment used in sandblasting. The product can be recyled and reused.

A wide variety of materials can be used as substitutes to silica in abrasive blasting.

- *coal slag* — this is a by-product of burning coal for electric power generation. It can contain high levels of heavy metals such as arsenic, beryllium, chromium, nickel and lead.

- *copper slag* — this is a by-product of copper smelting. Its composition is variable, but can contain arsenic, beryllium, chromium, nickel and lead as well as copper.

- *garnet* — the almandite form of the mineral is the most common form used in abrasive blasting. The mineral is made up of a mixture of silicon dioxide, iron, and aluminum.

- *nickel slag* — a by-product of nickel smelting, this product may contain arsenic, chromium and lead as well as nickel.

- *olivine*— this mineral contains a high proportion of magnesium oxide and can also contain small amounts of chromium and nickel (0.1 to 0.4 percent).
- *specular hematite* — this is a form of crystalline iron oxide.
- *staurolite* — a naturally occurring mineral sand with crystals made up of aluminum, iron, silicon and oxygen.
- *steel grit*— this is a product manufactured from steel scrap that is low in sulfur and phosphorous and contains trace amounts of manganese, arsenic and nickel. The scrap is melted in a furnace to produce steel shot that is then crushed to produce steel grit. This material is the hardest metallic abrasive commercially available and can be recycled and reused.

Some of the alternatives to silica contain heavy metals for which there are also health concerns. A study that looked at copper slag, for example, showed that in a relatively short time the material could generate total particulate lead, arsenic and chromium exposures that exceeded permissible exposure limits. Researchers have also begun to investigate potential lung damage caused by silica substitutes. For example, some forms of aluminum oxide have been shown to cause pulmonary fibrosis in animals and humans.

Staurolite and garnet can contain low percentages of crystalline silica (quartz). If they are used in uncontrolled abrasive blasting operations, enough airborne respirable crystalline silica can be generated to exceed occupational exposure limits. Some studies have shown that olivine and coal slag are more toxic than silica sand. Copper and nickel slag were found to have a toxicity similar to that of silica sand.

A number of other abrasives are available that are softer than silica sand (plastic media, corn cobs, nut shells, dry ice pellets, glass beads and sodium bicarbonate). These materials are usually used to remove contaminants from more delicate surfaces, so are not usually appropriate for the same applications as silica sand. Where silica sand is chosen as an abrasive, the use of dust suppressants blended into the sand is recommended to help control dust.

Engineering controls

Engineering controls are mechanical processes used to eliminate exposure to a dust. Engineering controls remove the dust from the air or provide a barrier between the worker and the dust. Examples of engineering controls used to prevent exposure to crystalline silica include:

- wet processes such as wet abrasive blasting or wet cutting
- installing local ventilation hoods
- installing dust collection systems onto machines or equipment
- dust control additives
- enclosures around the work process
- automated processes e.g. robotics
- use of alternative equipment e.g. use of vacuums instead of compressed air lances or dry sweeping to remove debris from cracks in road repair.

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The National Institute of Occupational Safety and Health (NIOSH) provides some additional guidance on engineering controls for silica in construction. This information is available on line at:

www.cdc.gov/niosh/topics/silica/constructionControlMain.html

Properly working engineering controls eliminate or reduce the potential hazard. The controls only need to be installed once and do not place a physical burden on workers. However, an initial investment is required and the systems must be properly operated and maintained once installed.

Administrative controls

Work practices can be implemented at the workplace to reduce potential exposure to silica dust. Examples include:

- Educating workers to understand the hazards associated with crystalline silica. Workers must participate in training and monitoring programs.
- Using good hygiene practices — workers must not eat, drink or use tobacco products in areas contaminated by crystalline silica. The hands and face should be washed before eating, drinking or smoking.

- Ensuring that engineering controls and other equipment used to reduce exposure are used and maintained properly.
- Signage warning workers of the hazards and informing them about the required protective equipment needed in areas where they may be exposed to crystalline silica or the product is used.

Using work practices to reduce exposure is often less expensive than other control measures. However, workers must be trained, use the practices properly, and have their work activities monitored by the employer.

Work practices can be implemented to reduce potential exposure.

Personal protective equipment

If it is not practicable or feasible to use substitutes, engineering controls, or change work practices to control exposure, personal protective equipment is needed. To protect workers from inhaling airborne silica, respiratory protective equipment is used. Many types of respirators are available and it is important to select the correct one(s) for the work being done.

For more information

http://humanservices.alberta.ca/ppe004
Guideline for the Development of a Code of Practice for Respiratory Protective Equipment

http://humanservices.alberta.ca/ppe001
Respiratory Protective Equipment: An Employer's Guide

If it is not practicable or feasible to use substitutes, engineering controls or change work practices, respiratory protective equipment is needed.

In addition to respiratory protective equipment, workers need to be provided with appropriate protective clothing at the work site. This is done to make sure that street clothes do not become contaminated with silica. Eyes must also be protected to prevent silica particles from entering them and causing irritation or damage.

Although the use of personal protective equipment may initially seem to be less costly, workers need to be trained in how to use it. Employers need to monitor use and ensure that the protective equipment is maintained properly. Issues such as heat stress, restricted vision, and allergic reactions to the equipment material need to be evaluated when personal protective equipment is selected.

Regulatory requirements

Alberta's occupational health and safety legislation has general and specific requirements related to crystalline silica. Occupational Exposure Limits (OELs) for crystalline silica are provided in Table 2, Schedule 1 of the OHS Code. These limits apply to workers directly involved with tasks using crystalline silica, and also to workers in the workplace who may be exposed to dust indirectly from these operations.

Specific requirements include:

- definition of an "exposed worker" — a worker who reasonably may be expected to work in an a "restricted area" at least 30 days in a 12-month period. (A "restricted area" is an area of the worksite where there is a reasonable chance that the concentration of crystalline silica exceeds the OEL.)
- minimizing the release of crystalline silica to the air and keeping the worksite clear of unnecessary accumulations of silica dust
- training workers about the health hazards associated with exposure to crystalline silica
- health assessments for exposed workers
- requirements for personal protective equipment. In addition to the general requirements related to respiratory protective equipment, where a worker is carrying out abrasive blasting operations, the employer must ensure that the worker is provided with a hood supplied with air that is at a positive pressure not exceeding 140 kPa.

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Web Site

www.worksafe.alberta.ca

Getting copies of OHS Act, Regulation & Code:

Queen's Printer

www.qp.gov.ab.ca

☎ Edmonton 780-427-4952

Occupational Health and Safety

http://humanservices.alberta.ca/ohs-legislation

Call any Government of Alberta office toll-free Dial 310-0000, then the area code and telephone number you want to reach