Occupational Health Guideline for Crystalline Silica

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: SiO_2
- Synonyms: Quartz; coesite; cristobalite; tridymite
- Appearance and odor: Colorless, odorless solid. (Crystalline silica may be a component of many mineral dusts).

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for crystalline silica is (for respirable dust) 10 milligrams silica per cubic meter of air (mg/m^3) divided by the percent SiO_2 2 averaged over an eight-hour work shift, and(for total dust) 30 mg/m^3 divided by the percent SiO_2 2 averaged over an eight-hour work shift. NIOSH has recommended that the permissible exposure limit changed to 50 micrograms respirable free silica per cubic meter of air (ug/m^3) averaged over a work shift of up to 10 hours per day, 40 hours per week. Uncontrolled abrasive blasting with silica sand presents such a severe silicosis hazard that NIOSH has recommended that silica sand, or other materials containing more than one percent free silica, be prohibited as an abrasive substance in abrasive blasting operations. The NIOSH Criteria Document for Crystalline Silica should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Crystalline silica can affect the body if it is inhaled.

- **Effects of overexposure**

Exposure to crystalline silica dust may cause scarring of the lungs with cough and shortness of breath. This is called "Silicosis."

- **Reporting signs and symptoms**

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to crystalline silica.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to crystalline silica at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the respiratory system and cardiovascular system should be stressed.

—14" x 17" chest roentgenogram: Crystalline silica causes human lung damage. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Crystalline silica is reported to cause decreased pulmonary function. Periodic surveillance is indicated.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

Crystalline silica or quartz dust causes silicosis, a form of disabling, progressive, and sometimes fatal pulmonary fibrosis characterized by the presence of typical nodulation in the lungs. The earliest lesions are seen in the region of the respiratory bronchioles. Lymphatics become obliterated by infiltration with dust-laden macrophages and granulation tissue. Morphologically, the typical lesion of silicosis is a firm nodule composed of concentrically arranged bundles of collagen. These nodules usually measure between 1 to 10 mm in diameter and appear around blood vessels and beneath the pleura, as well as in mediastinal lymph nodes. There

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may be conglomeration of nodules as the disease progresses, leading to massive fibrosis. Histologically, the silicotic nodule consists of a relatively acellular, avascular core of hyalinized reticulin fibers arranged concentrically and blending with collagen fibers toward the periphery, which has well-defined borders. The particles of silica responsible for the reaction are birefringent and can be visualized under polarized light if they exceed 1 micrometer in diameter. Silica in the lungs can be identified by x-ray diffraction studies and by incinerating a portion of the lung, with subsequent analysis of the ash. The silica content of the normal lung should not exceed 0.2% dry weight. The clinical signs and symptoms of silicosis tend to be progressive with continued exposure to quantities of dust containing free silica, with advancing age, and with continued smoking habits. Symptoms may also be exacerbated by pulmonary infections and cardiac decompensation. Symptoms include cough, dyspnea, wheezing, and repeated nonspecific chest illnesses. Impairment of pulmonary function may be progressive. In individual cases there may be little or no decrement when simple discrete nodular silicosis is present, but when nodulations become larger or when conglomeration occurs, recognizable cardiopulmonary impairment tends to occur. Progression of symptoms usually continues after dust exposure ceases. While there may be a factor of individual susceptibility to a given exposure to silica dust, the risk of onset and the rate of progression of the pulmonary lesion is clearly related to the character of the exposure (dust concentration and duration). The disease tends to occur after an exposure measured in years rather than months. Occasionally, exposures to very high concentrations occur in short periods of time in occupations such as sandblasters and tunnel workers; in these cases of acute or rapidly-developing silicosis there may be severe respiratory symptoms resulting in death. It is generally accepted that silicosis predisposes to active tuberculosis, and that the combined disease tends to be more rapidly progressive than uncomplicated silicosis. A group of 972 granite-shed workers was studied to relate exposure levels to incidence of silicosis. The workers were grouped according to average exposure levels: 3 - 9, 20, 27 - 44, 37-60 particles per cubic foot (mppcf). Those with the highest dust exposure showed development of early silicosis in 40% of the workers after 2 years and 100% after 4 years of exposure. The development of silicosis in the remaining workers appeared to be proportional to the dust exposure. At the second highest exposure level (27-44 mppcf), early stages of silicosis appeared after 4 years of exposure and more advanced stages developed by the seventh year. In the group exposed at an average of 20 mppcf there was little indication of severe effects upon the health of the workers. In the lowest exposure group, where the average dust concentration was 6 mppcf (range 3 to 9 mppcf), there was no indication of any untoward effects of dust exposure on workers.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 60.1
  2. Boiling point (760 mm Hg): 2230 C (4046 F)
  3. Specific gravity (water = 1): 2.2 – 3.0
  4. Vapor density (air = 1 at boiling point of crystalline silica): Not applicable
  5. Melting point: 1600 C (2912 F)
  6. Vapor pressure at 20 C (68 F): Essentially zero
  7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
  8. Evaporation rate (butyl acetate = 1): Not applicable
- **Reactivity**
  1. Conditions contributing to instability: None
  2. Incompatibilities: Contact with powerful oxidizing agents such as fluorine, chlorine trifluoride, manganese trioxide, oxygen difluoride, etc. may cause fires.
  3. Hazardous decomposition products: None
  4. Special precautions: Crystalline silica is attacked by hydrogen fluoride (or hydrofluoric acid).
- **Flammability**
  1. Not combustible
- **Warning properties**

Grant states that crystalline silica "has been observed to cause fibrotic nodules in the eye analogous to pulmonary silicosis. Particles of silica predominantly in the range of 2u to 3u introduced into the corneal stroma of rabbit eyes cause very little reaction. The same particles introduced into the anterior chamber sink to the bottom of the chamber and in the course of three to five weeks cause an inflammatory reaction with formation of fibrotic nodules in the iridocorneal angle. The reaction is quite different and more severe than that induced by brickdust, glass, or magnesium silicate . . . .

"An apparently unique report of involvement of the cornea in foundry workers who developed pulmonary silicosis has described gradual decrease in visual acuity due to corneal opacities in the pupillary area and has reported spectroscopic analytical evidence of an abnormally high silicon content in the cornea."

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Sampling and analyses may be performed by collection of crystalline silica on a filter, followed by an x-ray diffraction analysis. A detailed analytical method for

diffraction analysis. An analytical method for crystalline silica is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to crystalline silica may occur and control methods which may be effective in each case:

Operation	Controls
Use in metallurgy industry for foundry molds, iron and steel castings, flux in smelting basic ores	Local exhaust ventilation; general dilution ventilation; wet process; personal protective equipment
Use in manufacture of fiberglass for electrical insulation, chemical filtration, and reinforcing fabrics	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Liberation from refining of sand for production of quartz	Process enclosure; local exhaust ventilation; water spray; personal protective equipment
Use in ceramics industry; use as an abrasive in scouring and polishing soaps and powders, flint sand paper, metal polishes, and sand blast work	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in processing synthetic quartz	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in manufacture of refractories and building products; use in manufacture of electrical instruments for piezoelectric properties	Local exhaust ventilation; general dilution ventilation; wet process; personal protective equipment
Use in grading and classification of electronic and optical grade quartz	Local exhaust ventilation; general dilution ventilation
Use in manufacture of optical equipment in prisms, wedges, and lenses	Local exhaust ventilation; general dilution ventilation; wet process; personal protective equipment
Use in a variety of processes as paint extender, lining for acid towers, in the chemical industry in dental composition, in rocket engines and spacecraft, and graining lithographic plates	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Liberation during granite and similar material processing	Local exhaust ventilation; general dilution ventilation; wet process; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If crystalline silica dust gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of crystalline silica dust, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or releases until cleanup has been completed.

• If crystalline silica is spilled or released in hazardous concentrations, the following steps should be taken:

1. Ventilate area of spill or release.

2. Collect spilled material in the most convenient and safe manner for reclamation or for disposal in a secured sanitary landfill.

• Waste disposal method:

Crystalline silica may be disposed of in a secured sanitary landfill.

ADDITIONAL INFORMATION

To find additional information on crystalline silica, look up crystalline silica in the following documents:

• Medical Surveillance for Chemical Hazards

• Respiratory Protection for Chemical Hazards

• Personal Protection and Sanitation for Chemical Hazards

• NIOSH Criteria Document for Crystalline Silica (November 1974)

These documents are available through the NIOSH Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

REFERENCES

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RESPIRATORY PROTECTION FOR CRYSTALLINE SILICA

Condition	Minimum Respiratory Protection* Required Above X** mg/m³
Particulate Concentration	
5X** mg/m³ or less	Any dust respirator.
10X** mg/m³ or less	Any dust respirator, except single-use or quarter-mask respirator. Any fume respirator or high efficiency particulate filter respirator. Any supplied-air respirator. Any self-contained breathing apparatus.
50X** mg/m³ or less	A high efficiency particulate filter respirator with a full facepiece. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
500X** mg/m³ or less	A powered air-purifying respirator with a high efficiency particulate filter. A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 500X** mg/m³ or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**X indicates the permissible exposure as defined above.