

Occupational Health Guideline for Amorphous 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: Diatomite; silicon dioxide (amorphous); diatomaceous earth; diatomaceous silica
- Appearance and odor: Colorless to gray odorless powder.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for amorphous silica is 20 million particles of amorphous silica per cubic foot of air (mppcf) averaged over an eight-hour work shift, or the quotient of 30 mg/m^3 divided by the percent of silica present. The American Conference of Governmental Industrial Hygienists has issued a Notice of Intended Changes of its recommended Threshold Limit Value for amorphous silica from 20 mppcf to 6 mg/m^3 total dust (all sampled dust) and 3 mg/m^3 for respirable dust.

HEALTH HAZARD INFORMATION

• Routes of exposure

Amorphous silica can affect the body if it is inhaled or if it comes in contact with the eyes.

• Effects of overexposure

Prolonged inhalation of amorphous silica including uncalcined diatomaceous earth may produce x-ray changes in the lungs without disability. Prolonged inhalation of calcined diatomaceous earth may cause silicosis with scarring of the lungs, cough, and shortness of breath.

• 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 amorphous silica.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to amorphous 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 should be stressed.

—14" x 17" chest roentgenogram: Although the contribution of amorphous silica including natural diatomaceous earth to the development of pneumoconiosis is unclear, surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Since persons with impaired pulmonary function may be at increased risk from exposure to amorphous silica, periodic surveillance is indicated.

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

• Summary of toxicology

Amorphous silica, including natural diatomaceous earth, is usually considered to be of low toxicity; however, pure amorphous silica is rarely found, and diatomaceous earth usually contains some amount of crystalline silica. When converted partially to a crystalline form by calcination, the dust of diatomaceous earth produces pulmonary fibrosis. Repeated exposure of guinea pigs to natural diatomaceous earth for periods up to 50 weeks to average concentrations ranging from 60 to 124 mg/m^3 caused thickening of the alveolar septa by infiltration of macrophages, accumulation of large numbers of multinuclear cells containing dust particles, and lymphadenopathy, but no proliferation of connective tissue. In a study of diatomaceous earth workers,

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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those employed in the quarry for more than 5 years and exposed only to natural diatomaceous earth had no significant roentgenologic changes; of others employed for more than 5 years in the milling process and exposed to calcined material, 17% had simple pneumoconiosis and 23% had the confluent form, probably the result of fibrogenic action of the crystalline silica formed by calcination of the naturally occurring mineral. In humans, calcined diatomaceous earth pneumoconiosis is characterized roentgenographically by fine linear and/or minute nodular shadows, either or both of which may be accompanied by conglomerate fibrosis; in the simple phase of the disease, the upper lobes, are affected more than the lower lobes and the condition progresses by an increase in the apparent number of the nodules, which rarely attain the density or size of nodules often seen in quartz silicosis. In the early confluent stage of the disease, the linear and nodular changes in the upper lung fields become more circumscribed and homogeneous; histologically, there is an absence of the focal, discrete, hyaline nodules or the whorled pattern of collagenous fibers of typical silicosis. The majority of experimental rats exposed to synthetic submicron amorphous silica at 1.5 mg/ft³ of air died from pulmonary vascular obstruction coupled with pulmonary insufficiency. Rats that survived recovered almost completely after 6 months.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 60.1
2. Boiling point (760 mm Hg): Not applicable
3. Specific gravity (water = 1): 2.65
4. Vapor density (air = 1 at boiling point of amorphous silica): Not applicable
5. Melting point: 1700 C (3100 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 fluorine, oxygen difluoride, and chlorine trifluoride will cause fire.
3. Hazardous decomposition products: None
4. Special precautions: None

• Flammability

1. Not combustible

• Warning properties

Grant states that "particles of silica predominantly in the range of 2u to 3u introduced into the corneal stroma of rabbit eyes cause very little reaction."

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 amorphous silica in an impinger, followed by dust counting utilizing an optical microscope. An analytical method for amorphous silica is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 6, 1980, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00369-6).

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 amorphous silica may occur and control methods which may be effective in each case:

Operation	Controls
Liberation during preparation by crushing, screening, calcining, and packing operations for industrial processes	Process enclosure; local exhaust ventilation; personal protective equipment
Liberation during mining and quarrying operations in extraction	Process enclosure; local exhaust ventilation; personal protective equipment

Operation

Use in manufacture of insulating materials including firebrick, insulation blocks, pipe covering, roofing felt, and asbestos panels

Use as a filter medium in food and beverage manufacture including sugar refining, brewing, wine and spirit manufacture, soft drinks, and purification of oils and fats

Use in manufacture of construction bonding materials including stucco, concrete, cement, plaster, and asphalt; manufacture of abrasive cleaning and polishing agents including scouring and polishing soaps and powders

Use in manufacture of surface coatings as porous extender and flattening agent in paint; as a filler agent for paints, lacquers, and varnishes; filler in paper manufacture, agricultural chemicals, and mineral filler in manufacture of plastics and vinyls

Use in dry grinding operations including grinding and polishing with natural abrasive wheels; manufacture of absorbent floor cleaning agents for use in industry, refineries, and gas stations; use as a parting powder in foundry operations

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Operation

Use in manufacture of pharmaceuticals and as a constituent of pill masses, dentifrices, and salves; use in pottery manufacture in glazes and bodies; use in water treatment; use as a carrier for nickel catalysts in petroleum and petrochemical industries

Controls

Process enclosure; local exhaust ventilation; 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 amorphous silica including diatomaceous earth 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.

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 amorphous silica is spilled or potentially hazardous quantities are released, 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:

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

REFERENCES

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RESPIRATORY PROTECTION FOR AMORPHOUS SILICA (INCLUDING NATURAL AND DIATOMACEOUS EARTH)

Condition	Minimum Respiratory Protection* Required Above 20 mppcf
Particulate Concentration	
100 mppcf or less	Any dust and mist respirator.
200 mppcf or less	Any dust and mist 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.
1000 mppcf 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.
10,000 mppcf 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 10,000 mppcf 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.