

**criteria for a recommended standard . . . .**

**OCCUPATIONAL EXPOSURE  
TO  
CRYSTALLINE SILICA**



**U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE**

**Public Health Service**

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## PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards at their workplace. The National Institute for Occupational Safety and Health has projected a formal system of research, with priorities determined on the basis of specified indices, to provide relevant data from which valid criteria for effective standards can be derived. Recommended standards for occupational exposure, which are the result of this work, are based on the health effects of exposure. The Secretary of Labor will weigh these recommendations along with other considerations such as feasibility and means of implementation in developing regulatory standards.

It is intended to present successive reports as research and epidemiologic studies are completed and sampling and analytical methods are developed. Criteria and standards will be reviewed periodically to ensure continuing protection of the worker.

I am pleased to acknowledge the contributions to this report on crystalline silica by members of my staff and the valuable constructive comments by the Review Consultants on Crystalline Silica, by the ad hoc committees of the American Industrial Hygiene Association and the Society for Occupational and Environmental Health, by Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, and by Edwin C. Hyatt, NIOSH consultant on respiratory protection. The NIOSH recommendations for standards are not necessarily a consensus of all the consultants and

professional societies that reviewed this criteria document on crystalline silica. Lists of the NIOSH Review Committee members and of the Review Consultants appear on the following pages.



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CRITERIA DOCUMENT: RECOMMENDATIONS FOR AN  
OCCUPATIONAL EXPOSURE STANDARD FOR CRYSTALLINE SILICA

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## I. RECOMMENDATIONS FOR A CRYSTALLINE SILICA STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that employee exposure to crystalline silica in the workplace be controlled by adherence to the following sections. The standard is designed to protect the health and safety of workers for up to a 10-hour workday, 40-hour workweek, over a working lifetime. Compliance with the standard should prevent adverse effects of crystalline silica on the health and safety of workers. The standard is measurable by techniques that are valid, reproducible, and available to industry and government agencies and are attainable with existing technology. The criteria and the standard recommended in this document will be subject to review and revision as necessary.

Crystalline silica, hereafter referred to in this document as free silica, is defined as silicon dioxide ( $\text{SiO}_2$ ). "Crystalline" refers to the orientation of  $\text{SiO}_2$  molecules in a fixed pattern as opposed to a nonperiodic, random molecular arrangement defined as amorphous. The three most common crystalline forms of free silica encountered in industry are quartz, tridymite, and cristobalite. Micro- and crypto-crystalline varieties of free silica, also included in the recommended standard, are composed of minute grains of free silica cemented together with amorphous silica and include tripoli, flint, chalcedony, agate, onyx, and silica flour. Other forms of free silica which, upon analysis, are found to have a crystalline structure as part of their composition are also subject to the recommended standard.

"Exposure to free silica" means exposure of the worker to an airborne concentration of free silica greater than half of the recommended environmental level in the workplace. Worker exposure at lower environmental concentrations will not require adherence to the following sections.

Section 1 - Environmental (Workplace Air)

(a) Concentration

Occupational exposure shall be controlled so that no worker is exposed to a time-weighted average (TWA) concentration of free silica greater than 50 micrograms per cubic meter of air (50  $\mu\text{g}/\text{cu m}$ ; 0.050  $\text{mg}/\text{cu m}$ ) as determined by a full-shift sample for up to a 10-hour workday, 40-hour workweek.

(b) Sampling, Calibration, and Analysis

Exposure to free silica shall be determined by a personal (breathing zone) sample.

Procedures for sampling, calibration of equipment, and analysis of environmental samples shall be as provided in Appendices I and II, or by methods shown to be equivalent in sensitivity, accuracy, and precision to the method specified.

Section 2 - Medical

(a) Medical examinations shall be made available to all workers subject to "exposure to free silica" prior to employee placement and at

least once each 3 years thereafter. Examinations shall include as a minimum:

(1) A medical and occupational history to elicit data on worker exposure to free silica and signs and symptoms of respiratory disease.

(2) A chest roentgenogram (posteroanterior 14" by 17" or 14" by 14") classified according to the 1971 ILO International Classification of Radiographs of Pneumoconioses. [ILO U/C International Classification of Radiographs of Pneumoconioses 1971, Occupational Safety and Health Series 22 (rev). Geneva, International Labor Office, 1972]

(3) Pulmonary function tests including forced vital capacity (FVC) and forced expiratory volume at one second (FEV 1) to provide a baseline for evaluation of pulmonary function and to help determine the advisability of the workers using negative- or positive-pressure respirators. It should be noted that pulmonary function tests may vary significantly in various ethnic groups. For example, the average healthy black male may have an approximately 15% lower FVC than a healthy caucasian male of the same body build.

(4) Body weight.

(5) Height.

(6) Age.

(7) Initial medical examinations for presently employed workers shall be offered within 6 months of the promulgation of a standard incorporating these recommendations.

(b) Medical Management

An employee with or without roentgenographic evidence of silicosis who has respiratory distress and/or pulmonary functional impairment should be fully evaluated by a physician qualified to advise the employee whether he should continue working in a dusty trade.

(c) These records shall be available to the medical representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, of the employee or former employee and of the employer.

(d) Medical records shall be maintained for at least 30 years following the employee's termination of employment.

Section 3 - Labeling (Posting)

(a) The following warning shall be posted to be readily visible at or near entrances or accessways to work areas where there is potential exposure to free silica.

WARNING!

FREE SILICA WORK AREA

Unauthorized Persons Keep Out

(b) The following warning shall be posted in readily visible locations in any work area where there is potential exposure to free silica.

WARNING!

FREE SILICA WORK AREA

Avoid Breathing Dust

May Cause Delayed Lung Injury (Silicosis)

The posting required under sections 3(a) and 3(b) shall be printed both in English and in the predominant language of non-English-speaking workers, unless they are otherwise trained and informed of the hazardous areas. Illiterate workers shall receive such training.

(c) The following warning label, in addition to or in combination with labels required by other statutes, regulations, or ordinances, shall be affixed to all new materials, mixtures, and other products containing more than 5% free silica, or to their containers.

WARNING!

CONTAINS FREE SILICA

DO NOT BREATHE DUST

May Cause Delayed Lung Injury (Silicosis)

Section 4 - Personal Protective Equipment and Work Clothing

Engineering controls shall be used to maintain free silica dust exposures below the prescribed limit. Subsection (a) shall apply whenever a variance from the standard recommended in Section 1 is granted under provisions of the Occupational Safety and Health Act, or in the interim period during the application for a variance. When the limits of exposure

to free silica prescribed in paragraph (a) of Section 1 cannot be met by limiting the concentration of free silica in the work environment, an employer must utilize, as provided in subsection (a) of this section, a program of respiratory protection to effect the required protection of every worker exposed.

(a) Respiratory Protection

Appropriate respirators, as prescribed in Table I-1, shall be provided and used when a variance has been granted to allow respirators as a means of control of exposure to routine operations and while the application is pending. Administrative controls may also be used to reduce exposure. Respirators shall also be provided and used for nonroutine operations (occasional brief exposures above the environmental standard and for emergencies); however, for these instances a variance is not required but the requirements set forth below continue to apply. Appropriate respirators as described in Table I-1 shall only be used pursuant to the following requirements:

(1) For the purpose of determining the type of respirator to be used, the employer shall measure the atmospheric concentration of free silica in the workplace when the initial application for variance is made and thereafter whenever process, worksite, climate, or control changes occur which are likely to affect the free silica concentration. This requirement shall not apply when only atmosphere-supplying positive pressure respirators are used. The employer shall ensure that no worker is exposed to free silica in excess of the standard because of improper respirator selection, fit, use, or maintenance.

(2) Employees experiencing breathing difficulty while using respirators shall be evaluated by a physician to determine the ability of the worker to wear a respirator.

(3) A respiratory protective program meeting the requirements of Section 1910.134 of the Occupational Safety and Health Standards shall be established and enforced by the employer. [29 CFR 1910.134 published in the Federal Register, vol 39, page 23671, dated June 27, 1974, as amended]

(4) The employer shall provide respirators in accordance with Table I-1 and shall ensure that the employee uses the appropriate respirator.

(5) Respiratory protective devices in Table I-1 shall be those approved either under 30 CFR 11, published March 25, 1972, or under the following regulations:

(A) Filter-type dust, fume, and mist respirators--  
30 CFR 14 (Bureau of Mines Schedule 21B)

(B) Supplied air respirator--30 CFR 12 (Bureau of  
Mines Schedule 19B)

(6) A respirator specified for use in higher concentrations of free silica may be used in atmospheres of lower concentrations.

(7) Employees shall be given instruction on the use of respirators assigned to them, on cleaning respirators, and on testing for leakage.

TABLE I-1

REQUIREMENTS FOR RESPIRATOR USAGE AT  
CONCENTRATIONS ABOVE THE STANDARD

Concentrations of Free Silica in Multiples of the Standard	<u>Respirator Type*</u>
Less than or equal to 5x	Single use (valveless type) dust respirator.
Less than or equal to 10X	Quarter or half mask respirator with replace- able dust filter or single use (with valve) dust respirator.  Type C, demand type (negative pressure), with quarter or half mask facepiece.
Less than or equal to 100X	Full facepiece respirator with replaceable dust filter.  Type C, supplied air respirator, demand type (negative pressure), with full facepiece.
Less than or equal to 200X	Powered air-purifying (positive pressure) respirator, with replaceable applicable filter.**
Greater than 200X	Type C, supplied air respirator, continuous flow type (positive pressure), with full facepiece, hood, or helmet.

\*Where a variance has been obtained for abrasive blasting with silica sand, use only Type C continuous flow, supplied air respirator with hood or helmet.

\*\*An alternative is to select the standard high efficiency filter which must be at least 99.97% efficient against 0.3  $\mu$ m dioctyl phthalate (DOP).

(b) Work Clothing

Where exposure to free silica is above the recommended environmental limit, work clothing shall be vacuumed before removal. Clothes shall not be cleaned by blowing or shaking.

Section 5 - Informing Employees of Hazards from Free Silica

(a) Each employee exposed to free silica shall be apprised at the beginning of his employment or assignment to a free silica exposure area of the hazards, relevant symptoms, appropriate emergency procedures, and proper conditions and precautions for safe use or exposure. The employee shall be instructed as to availability of such information including that prescribed in (b) below. Such information shall be kept on file and shall be accessible to the worker at each place of employment where free silica is involved in unit processes and operations. Workers shall also be advised of the increased risk of impaired health due to the combination of smoking and free silica dust exposure.

(b) Information, to the extent applicable to free silica, as specified in Appendix III shall be recorded on US Department of Labor Form OSHA-20, "Material Safety Data Sheet" (see Appendix III) or on a similar form approved by the Occupational Safety and Health Administration, US Department of Labor.

Section 6 - Work Practices and Control Procedures

(a) Substitution

(1) Wherever a hazard of silicosis can be eliminated by a reasonable substitution of other less toxic materials for free silica, the substitution shall be made unless the silica sand has been so processed before use to make it nonrespirable such as by washing to remove fine particles. Examples of such substitution are the use of alumina instead of

flint for china placing in potteries, and the substitution of a quartz-free grit in abrasive blasting.

(2) Uncontrolled abrasive blasting with silica sand is such a severe silicosis hazard that special attention must be given to this problem. Silica sand, or other materials containing more than 1% free silica, should be prohibited as an abrasive substance in abrasive blasting cleaning operations.

(b) Dust suppression

Moisture shall be added where such addition can substantially reduce the exposure to airborne respirable free silica dust.

(c) Ventilation

Where a local exhaust ventilation and collection system is used, it shall be designed and maintained to prevent the accumulation or recirculation of free silica dust into the workplace. The total system shall be inspected periodically for efficiency of operation. In addition, necessary measures shall be taken to ensure that discharge outdoors will not produce a health hazard to humans, animals, or plants.

(d) General Housekeeping

(1) Cleaning by blowing with compressed air or dry sweeping shall be avoided and dustless methods of cleaning such as vacuuming or washing down with water shall be substituted.

(2) Emphasis shall be placed upon cleanup of spills, preventive maintenance and repair of equipment, proper storage of materials, and collection of dusts containing free silica. Sanitation shall meet the requirements of 29 CFR 1910.141 as amended.

## Section 7 - Monitoring and Recordkeeping Requirements

Work environments where it has been determined, on the basis of a professional industrial hygiene survey or by the judgment of a compliance officer, that the workers' exposure does not exceed half of the standard shall not be considered to have exposure to free silica. Records of these surveys, including the basis for concluding that air levels are at or below half of the standard shall be maintained. Surveys shall be repeated when any process change indicates a need for reevaluation or at the discretion of the compliance officer. Requirements set forth below apply to areas in which there is "exposure to free silica."

Employers shall maintain records of the workers' exposure to free silica based upon the following sampling and recording schedules:

(a) In all monitoring, samples representative of the exposure in the breathing zone of employees shall be collected. An adequate number of samples shall be collected to permit construction of a full-shift exposure for every operation or process. The minimum number of time-weighted average determinations for an operation or process shall be based on the number of workers exposed as provided in Table I-2 or as otherwise indicated by a professional industrial survey.

(b) The first work environment (breathing zone) sampling shall be completed within 6 months of the promulgation of a standard incorporating these recommendations.

(c) Work environment (breathing zone) samples shall be taken within 30 days after installation of a new process or process changes.

TABLE I-2

## SAMPLING SCHEDULE

<u>Number of Employees Exposed</u>	<u>Number of Time-weighted Average Determinations</u>
1-20	50% of the total number of workers
21-100	10 plus 25% of the excess over 20 workers
over 100	30 plus 5% of the excess over 100 workers

(d) Samples shall be collected and analyzed at least every 6 months in accordance with Appendices I and II for the evaluation of the workers' exposure with respect to the recommended standard.

(e) When monitoring of the workers' exposure indicates a free silica concentration in excess of the recommended standard, suitable controls shall be initiated to reduce the exposure level to or below the recommended standard. In such cases monitoring shall continue at 30-day intervals until 2 consecutive surveys indicate the recommended standard is no longer exceeded. Periodic review and evaluation of environmental and medical data shall be performed to determine the effectiveness of control measures.

(f) Records shall be maintained of medical examinations and all sampling schedules to include the sampling and analytical methods, type of personal protection devices, if any, in use at the time of sampling and the determined free silica dust concentration. Records shall be maintained for at least 30 years following termination of workers' employment. Each employee shall be able to obtain information on his exposure.

## II. INTRODUCTION

This report presents the criteria and the recommended standard based thereon which were prepared to meet the need for preventing occupational diseases arising from exposure to crystalline variants of free silica. The document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20 (a)(3) of the Occupational Safety and Health Act of 1970 to "... develop criteria dealing with toxic materials and harmful physical agents and substances which will describe... exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

The National Institute for Occupational Safety and Health (NIOSH), after a review of data and consultation with others, formalized a system for the development of criteria upon which standards can be established to protect the health of workers from exposure to hazardous chemical and physical agents. It should be pointed out that any recommended criteria for a standard should enable management and labor to develop better engineering controls resulting in more healthful work practices and should not be accepted as a final goal.

These recommendations for a standard for free silica are part of a continuing series of criteria being developed by NIOSH. The recommended standard applies to the processing, manufacture, and use of free silica as applicable under the Occupational Safety and Health Act of 1970.

These recommendations are not developed for the population-at-large and any extrapolation beyond general occupational exposure is not warranted. They are intended to assure that the standard based thereon will (1) protect against development of acute and chronic fibrogenic disease (silicosis) or functional incapacities arising from inhalation of free silica; (2) be measurable by techniques that are valid, reproducible, and available to industry and governmental agencies; and (3) be attainable with existing technology.

Criteria presented in this document do not pertain to amorphous, noncrystalline forms of silica.