



Designation: E1132 – 06

Standard Practice for Health Requirements Relating to Occupational Exposure to Respirable Crystalline Silica¹

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INTRODUCTION

Silicon dioxide (silica, SiO₂) is encountered in nature and industry in a wide variety of forms. These range from essentially anhydrous types with or without a very high degree of crystallinity, to highly hydroxylated or hydrated types which are amorphous by x-ray diffraction examination. Crystalline silica² exists in a number of forms or polymorphs. The three major forms, quartz, cristobalite, and tridymite, pertain to this practice. Quartz (or alpha quartz) is the more common form encountered as airborne particulates. Two of the polymorphs, cristobalite and tridymite, are formed at elevated temperatures and are much less common in nature, but might be encountered in several occupations where silicas are fired (calcined) at high temperatures.³ These silica materials have a broad range of physical and chemical properties.

1. Scope

1.1 This practice covers a description of several actions that should be taken to reduce the risk of harmful occupational exposures to humans in environments containing respirable crystalline silica. This practice is intended for, but not limited to, industries regulated by the U.S. Mine Safety and Health Administration (MSHA) and the U.S. Occupational Safety and Health Administration (OSHA). A separate practice, designed for the unique conditions of the construction industry is under development. While this practice was not designed specifically for construction, it can be applied and may be beneficial, to the extent feasible and practical, pending adoption of a construction industry standard.

1.2 Nothing in this practice shall be interpreted as requiring any action that violates any statute or requirement of any federal, state, or other regulatory agency.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate*

safety and health practices and determine the applicability of regulatory limitations prior to use. It is the responsibility of the user to consult all material safety data sheets and labels pertaining to any hazardous materials used in this standard.

2. Referenced Documents

2.1 *ASTM Standards:*⁴

[D4532 Test Method for Respirable Dust in Workplace Atmospheres Using Cyclone Samplers](#)

2.2 *ANSI Standards:*⁵

[ANSI/AIHA Z9.2 Fundamentals Governing the Design and Operation of Local Exhaust Systems](#)

[Z88.2 American National Standard Practice for Respiratory Protection](#)

2.3 *Code of Federal Regulations:*⁶

[29 CFR 1910.94, Ventilation](#)

[29 CFR 1910.134, Respiratory Protection](#)

[29 CFR 1910.1000, Air Contaminants](#)

[29 CFR 1910.1200, Hazard Communication](#)

[30 CFR 47, Hazard Communication](#)

¹ This practice is under the jurisdiction of ASTM Committee E34 on Occupational Health and Safety and is the direct responsibility of Subcommittee E34.16 on Silicas.

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² Smith, Deane K., Opal, cristobalite, and tridymite: Noncrystallinity versus crystallinity, nomenclature of the silica minerals and bibliography, *Powder Diffraction*, Vol 13, 1998, pp. 1–18.

³ Miles, W. J., Crystalline silica analysis of Wyoming bentonite by X-ray diffraction after phosphoric acid digestion, *Analytical Chemistry Acta*, Vol 286, 1994, pp. 97–105.

⁴ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁶ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

30 CFR 56, Title 30, Subpart D, Air Quality, Radiation, and Physical Agents (MSHA)

42 CFR 84 Title 42, Part 84, Approval of Respiratory Protective Devices, Tests for Permissibility, Fees

2.4 NIOSH Publications:⁷

Manual of Analytical Methods, 4th Ed., DHHS (NIOSH), Publication No. 94-113, August 1994

Method 7500 for Silica, Crystalline, Respirable (XRD)

Method 7601 for Silica, Crystalline Visible Absorption Spectrophotometry

Method 7602 for Silica, Crystalline (IR)

Method 7603 for Coal Mine Dust by IR

2000 Guidelines for the Use of ILO International Classification of Radiographs of Pneumoconioses

2.5 Other References:

National Industrial Sand Association, Occupational Health Program for Exposure to Crystalline Silica in the Industrial Sand Industry, March 1997

American Thoracic Society, Standardization of Spirometry

3. Significance and Use

3.1 These practices and criteria were developed for occupational exposures. They are intended to (a) protect against clinical disease from exposure to respirable crystalline silica, (b) be measurable by techniques that are valid, reproducible, and readily available, and (c) be attainable with existing technology and protective practices.

4. General Requirements

4.1 Occupational Exposure Limits (OEL):

4.1.1 Permissible Exposure Limit (PEL) established by U.S. Occupational Health and Safety Administration (OSHA) General Industry (see 29 CFR 1910.1000)—Workers shall not be exposed to respirable dust containing 1 % or more quartz exceeding $10/(\% \text{ quartz} + 2) \text{ mg/m}^3$ as an 8-h time weighted average in any 8-h work shift of a 40-h work week or, for total dust (respirable plus non-respirable), $30/(\% \text{ quartz} + 2) \text{ mg/m}^3$. The PEL for respirable cristobalite and tridymite is one-half the value for quartz.

4.1.1.1 PEL (mg/m^3) (respirable fraction):

$$10 \div [\% \text{ quartz} + (\% \text{ cristobalite} \times 2) + (\% \text{ tridymite} \times 2) + 2]$$

4.1.1.2 PEL (mg/m^3) (total dust):

$$30 \div [\% \text{ quartz} + (\% \text{ cristobalite} \times 2) + (\% \text{ tridymite} \times 2) + 2]$$

4.1.2 PEL established by U.S. Mine Safety and Health Administration (MSHA) (non-coal) (see 30 CFR 56.5001)—Workers shall not be exposed to respirable dust containing 1 % or more quartz exceeding the PEL as determined for a time weighted 8-h workday and 40-h workweek based on the following formula: $\text{PEL} = 10/(\% \text{ quartz} + 2) \text{ mg/m}^3$. The PEL for respirable cristobalite and tridymite is one-half the value for quartz.

4.1.3 Examples of other OELs are provided in Appendix X2.

⁷ Available from National Institute for Occupational Safety and Health, Division of Physical Sciences and Engineering, 4676 Columbia Parkway, Cincinnati, OH 45226.

4.1.4 Employers shall determine the appropriate OEL for their operation, but in no case shall the OEL be less stringent than the applicable government limit.

4.2 Exposure Assessment and Monitoring:

4.2.1 Risk can be assessed qualitatively based on Material Safety Data Sheets (MSDS), prior information, likelihood of dust generation, proximity of airborne dust to workers, nature of the industrial process (example: wet work—low risk; dry work—higher risk), and location of workers (example: control room). Note that the absence of visible dust is not a guarantee of lack of risk.

4.2.2 Initial sampling of representative workers' exposures shall be made to characterize the exposure and its variability, to determine compliance with standards given in 4.1, and to establish a baseline exposure level in all areas where workers are or may be exposed to silica. Initial task sampling would be not required for short duration or transient tasks, tasks where timely sampling results would not be available, representative concentrations are already known, and proven task protection is in place. Exposure sampling should be periodic, and should occur frequently enough that a significant and deleterious change in the contaminant generation process or the exposure controls is not permitted to go undetected. This is particularly true for areas or operations where conditions can change dramatically within a short span of time.

4.2.3 When sampling is conducted, workers with a high relative risk of dust exposure should be sampled first. Sampling should then progress toward those individuals with low exposure risk. High relative risk can be assigned to any area where the process involved may generate respirable crystalline silica particles and persons are potentially exposed for most or all of a work shift.

4.2.4 Employers shall sample occupational exposures of workers exposed to respirable crystalline silica and maintain records of such sampling.

4.2.5 For workers with regular exposure to high silica concentrations that are placed inside of supplied air respirators or ventilated enclosures, such as in sandblasting, sampling should be conducted inside of the control device to determine employee exposure. The sampling line shall not interfere with the fit of the respirator. Consultation with the respirator manufacturer may be necessary to achieve the above requirement.

4.2.6 In areas where overexposures are persistent, a written Exposure Control Plan shall be established to implement engineering, work practice, and administrative controls to reduce silica exposures to below the OEL, or other elected limit, whichever is lower, to the extent feasible. A root cause analysis should be conducted for all exposures in excess of the OEL that cannot be accounted for. Root cause analysis involves investigating cause(s) for the excessive exposure, providing remedies, and conducting follow-up sampling to document that exposures are below the OEL.

4.2.7 Sampling shall be done at a frequency that provides reliable information for determining an appropriate control strategy. Sampling information and recommended frequency is summarized in Table 1.

TABLE 1 Sampling Information

Condition	Action
Qualitative assessment	Based on evaluation of process and materials used and visual review of dust generation potential.
Initial sampling	Conducted at representative job functions starting with assumed highest dust exposure levels. Results used to establish sampling plan.
Sampling results are below one half the OEL	No periodic sampling necessary but additional samples may be required due to process changes.
No OEL overexposures were found, but exposures exceed one half the OEL	These noted locations are to be included in a sampling plan. Noted job functions should be sampled at least annually with a goal of sampling each employee with that job function within a 3 year period.
OEL was exceeded and engineering, work practice, and administrative controls, or all three, are being applied to the work area to reduce exposures to below the OEL (see 4.2.6)	Sampling to be conducted before and after the remedy to assess the results of silica reduction efforts. If high levels persist institute workplace controls and include in sampling plan until levels are below one half the OEL.
Process materials, process equipment, engineering controls, or any other changes that occur which would tend to increase worker exposures	Sampling to be conducted as soon as feasible to assess the effects of workplace changes on worker exposures.
Ventilated protective enclosures are used because work area exposures are presumed or known to exceed the OEL	Sample at least annually to ensure that worker exposures do not exceed one-half the OEL.
Short duration (hours or less) silica dust generation operations such as drilling and cutting	Depend on workplace controls to reduce exposures. Sampling only provides historical data since the operation will have ended before sample analysis results are available.
Worker(s) or supervision express concerns that silica exposures have increased.	Review and discuss concerns and sample as soon as necessary to determine exposures.

mation. See Figs. X1.1-X1.3 for example sampling record, calibration forms, and employee notification of dust sampling results.

4.2.12 Samples for silica analysis should be analyzed by an AIHA-accredited laboratory.

4.3 Observation of Exposure Monitoring:

4.3.1 *Employee Observation*—The employer shall provide affected employees or their designated representatives an opportunity to observe any monitoring of employee exposure to silica and provide an explanation of the sampling procedure.

4.3.2 *Monitoring Procedures*—Whenever observation of the monitoring of employee exposure to respirable crystalline silica requires entry into an area where the use of respirators, protective clothing, or equipment is required, the employer shall provide and ensure the use of such personal protective equipment and shall require compliance with all other applicable safety and health procedures.

4.3.3 *Monitoring Results*—Observers shall be entitled to:

4.3.3.1 Receive an explanation of the measurement and analytical procedures,

4.3.3.2 Observe all steps related to the monitoring of respirable crystalline silica performed at the place of exposure, and

4.3.3.3 Record the results obtained for any real-time instruments and/or obtain copies of printouts or downloadable data files from those instruments. They should also be entitled to receive copies of the results when returned by the laboratory and to obtain explanations if they have questions about the data.

4.4 Methods of Compliance:

4.4.1 The methods listed below are applicable where compliance is required because of personal exposures exceeding the OEL or a company-adopted exposure limit.

NOTE 1—One half the exposure limit is frequently used by employers as a warning since excursions above the exposure limit are possible.

4.4.2 Engineering Controls:

4.4.2.1 Use of properly designed engineering controls is the most desirable approach for controlling dust from crystalline silica-containing materials.

4.4.2.2 Adequate ventilation or other dust suppression methods shall be provided to reduce respirable crystalline silica concentrations to below the OEL, where feasible.

4.4.2.3 Enclosed workstations, such as control booths and equipment cabs, designed for protection against respirable crystalline silica dust, shall be under positive pressure and provided with clean make-up air. Re-circulation of air is not preferred; however, properly designed and maintained re-circulation systems are acceptable. Re-circulated air inside enclosed workstations should be in accordance with NIOSH guidance.

4.4.2.4 Engineering design of equipment shall include, where feasible, provisions to reduce exposure of workers to respirable crystalline silica dust to the OEL or below. If ventilation systems are used, they shall be designed and maintained to prevent the accumulation and re-circulation of respirable crystalline silica dust in the working environment (see ANSI Z9.2). If wet suppression systems are used, spray nozzles and associated piping shall be maintained to ensure

4.2.8 Because people have different work habits, sampling should be rotated among different employees performing the same task with a goal of sampling each individual at least once every three years or use statistical random sampling.

4.2.9 Measurement of worker occupational exposures shall be within the worker's breathing zone and shall meet the criteria of this section. Such measurements should be representative of the worker's customary activity and should be representative of workshift exposure. Area sampling may be used to characterize exposures and identify effective controls when appropriate to the circumstances.

4.2.10 Respirable dust samples are to be collected according to accepted methods. Refer to Test Method D4532 and see Appendix X1 for an example.

4.2.11 Sampling data records shall include employee identification, a log of the date and time of sample collection, sampling time duration, volumetric flow rate of sampling, documentation of pump calibration, description of the sampling location, analytical methods, and other pertinent infor-

that adequate wetting agent is applied where needed to control respirable crystalline silica dust. If hand-held or stationary tools are cut, grind or drill silica containing materials they should be designed and/or used in a manner to reduce dust exposures.

4.4.2.5 All engineering controls shall be properly maintained and periodically evaluated and brought up to specifications, when needed.

4.4.3 *Work Practices and Administrative Controls:*

4.4.3.1 Workers should not work in areas of visible dust generated from respirable crystalline silica-containing materials without use of respiratory protection, unless proven task protection is in use or air sampling shows exposures less than the OEL.

4.4.3.2 To the extent feasible, dry sweeping shall not be used in work areas where employees could reasonably be expected to be exposed to respirable crystalline silica above the OEL.

4.4.3.3 Workers shall not use compressed air to blow respirable crystalline silica-containing materials from surfaces or clothing, unless the method has been approved by an appropriate Regulatory agency.

4.4.3.4 Employers shall instruct workers about specific work practices that minimize exposure to respirable crystalline silica. Workers will perform their work tasks in accordance with these instructions.

4.4.3.5 Workers shall practice good housekeeping practices to minimize the generation and accumulation of dust.

4.4.3.6 Workers shall utilize available means to reduce exposure to dust, including the use of respirators, control rooms or rest areas, ventilation systems, high efficiency particulate air (HEPA) vacuum cleaners or water spray, wet floor sweepers, and rotation of personnel to minimize individual exposure.

4.5 *Respiratory Protection:*

4.5.1 Respirators shall be required in work situations in which engineering and work practice controls are not sufficient to reduce exposures of employees to or below the applicable OEL or company adopted level. Where the use of personal respiratory protection is required under this practice, the employer shall establish and enforce a program to include the following elements of a respiratory protection program, as specified and detailed in 29 CFR 1910.134 and ANSI Z88.2, for exposed workers. Respirators must comply with the requirements contained herein.

4.5.2 When respirators are used by this practice, the employer shall select a respirator certified by NIOSH under the provisions of 42 CFR 84 that has an assigned protection factor (APF) greater than the hazard ratio (HR) as determined by air sampling and analysis. The HR is defined as the ratio of the ambient concentration to the exposure limit. The APF values are given in **Table 2**. All respirators must be approved for use against silica type dusts. Respirators must comply with requirements of ANSI Z88.2. See **Table 2** for recommended respiratory protection.

4.5.3 Employers shall perform respirator fit tests in accordance with ANSI Z88.2 at the time of initial fitting and at least annually, thereafter, for each worker wearing tight-fitting

TABLE 2 Recommended Respiratory Protection for Workers Exposed to Respirable Crystalline Silica

APF ^A	Minimum Respiratory Protection for Crystalline Silica ^B
10	any air-purifying respiratory with any Part 84 particulate filter (N,R, or P, as appropriate).
25	any powered, air-purifying respirator with a high-efficiency particulate filter, or any supplied-air respirator equipped with a hood or helmet and operated in a continuous-flow mode (for example, type CE abrasive blasting respirators operated in the continuous-flow mode)
50	any air-purifying, full-facepiece respirator with a 100 series (N,R, or P) Part 84 particulate filter, or any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter
1000	any supplied-air respirator equipped with a half-mask and operated in a pressure-demand or other positive-pressure mode
2000	any supplied-air respirator equipped with a full facepiece, hood or helmet and operated in a pressure-demand or other positive-pressure mode (for example, a type CE abrasive blasting respirator operated in a positive-pressure mode)
Planned or emergency entry into environments containing unknown concentrations or concentrations 10 000	any self-contained breathing apparatus equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode, or any supplied-air respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive-pressure mode
Firefighting	any self-contained breathing apparatus equipped with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	any air-purifying, full facepiece respirator with a high-efficiency particulate filter, or any appropriate escape-type, self-contained breathing apparatus
Abrasive blasting	per 29 CFR 1910.94, NIOSH approved Type CE Abrasive-blasting rooms, or when using silica sand in manual blasting operations where the nozzle and blast are not physically separated from the operator in an exhaust ventilated enclosure, or where concentrations of toxic dust dispersed by the abrasive blasting may exceed the limits wet in 1910.1000 and the nozzle and blast are not physically separated from the operator in an exhaust-ventilated enclosure

^A Assigned protection factor (APF). The APF is the minimum anticipated level of protection provided by each type of respirator.

^B Only NIOSH/MSHA approved equipment should be used. These recommendations are intended to protect workers from silicosis.

respirators. The tests shall be used to select respirators that provide the required protection.

4.5.4 The employer shall institute a respiratory protection program that includes: individual medical clearance for respirator usage, worker training in the use and limitations of respirators, routine air monitoring, and the inspection, cleaning, maintenance, selection, and proper storage of respirators. This training shall be done at first employment and annually as refresher training. Any respiratory protection must,

at a minimum, meet the requirements of 29 CFR 1910.134 and ANSI Z88.2. Respirators should be used according to the manufacturer's instructions.

4.5.4.1 Each potential respirator wearer will receive medical clearance prior to the issuance of a respirator and subsequent fit testing. Detailed guidance is provided at 29 CFR 1910.134. Medical clearance is the process to determine an individual's psychological and medical functional-ability to wear a respirator.

4.6 *Respiratory Medical Surveillance:*

4.6.1 The employer shall institute a respiratory medical surveillance program for all workers who work in areas, for 120 days per year or more, where the TWA concentration of respirable crystalline silica dust exceeds the OEL (see 4.1) or a lower company adopted OEL, or where such concentrations are anticipated.

4.6.2 All medical examinations and medical procedures as required under 4.6 are to be performed by or under the direction of a licensed physician, and are provided without cost to the worker.

4.6.3 The employer shall provide the required medical surveillance to the workers and at a reasonable time and place.

4.6.4 Persons who administer the pulmonary function testing shall demonstrate proficiency in spirometry using the American Thoracic Society "Standardization of Spirometry."

4.6.5 Medical examinations shall be made prior to placement of new workers (as defined in 4.6.1), and no less than once every three years thereafter. These examinations shall include as a minimum:

4.6.5.1 Medical and occupational history to elicit information on respiratory symptoms, smoking history, and prior exposures to dust and agents affecting the respiratory system. See Fig. X1.4 for example.

4.6.5.2 A posterior-anterior (PA) chest roentgenogram on a film no less than 14 by 17 in. and no more than 16 by 17 in. at full inspiration. The roentgenogram shall be classified according to the 2000 Guidelines for the Use of ILO International Classification of Radiographs of Pneumoconioses by currently NIOSH certified "B" readers. NIOSH "B" readers are physicians that have demonstrated proficiency in the classification of roentgenograms according to the ILO system by successfully completing a practical examination.

4.6.5.3 A tuberculosis intradermal skin test using purified protein derivative for workers with roentgenographic evidence of silicosis who have not been tested.

4.6.5.4 Spirometry is an OPTIONAL component of this practice. There is currently no evidence that routine medical surveillance with spirometry is useful for early detection of silica-induced lung disease. Experience has shown that most abnormalities on screening spirometry are not due to work-related disorders. Smoking, non-occupational pulmonary disease, and other variables are more common causes of alterations in pulmonary function. Provided spirometry is conducted, pulmonary function measurements should include a determination of forced vital capacity (FVC), forced expiratory volume in 1 s (FEV₁), and forced expiratory volume in 1 s as a percentage of total forced vital capacity (FEV₁/FVC%) and should be obtained. Spirometry results should be compared

with the 95th-percentile lower limit of normal (LLN) values (see Hankinson et al, *Am J. Respiratory Critical Care Med.*, 1999 Jan, 159(1), pp. 179-87). Technicians performing spirometry test shall have attended a NIOSH certified spirometry training course (DHHS (NIOSH) Pub No. 2004-154c).

4.6.6 The employer shall provide the following information to the health care provider:

4.6.6.1 A copy of this practice with appendix,

4.6.6.2 A description of the affected worker's duties as they relate to the worker's exposure,

4.6.6.3 The worker's representative exposure level or anticipated exposure level to respirable crystalline silica,

4.6.6.4 A description of any personal protective and respiratory protective equipment used or to be used by the worker, and

4.6.6.5 Information from previous medical examinations of the affected worker that is not otherwise available to the health care provider.

4.6.7 The physician shall not reveal either in the written opinion, or in any other means of communication with the employer, findings, including laboratory results, or diagnoses unrelated to an employee's occupational exposure to crystalline silica.

4.6.7.1 The physician's opinion as to whether the worker has any detected medical conditions that would place the worker at an increased risk of material health impairment from exposure to respirable crystalline silica,

4.6.7.2 Any recommended limitations on the worker or upon the use of personal protective equipment such as clothing or respirators; for example, the fact that worker is medically or emotionally unable to wear a respirator,

4.6.7.3 A statement that the worker has been informed by the physician of the results of the medical examination and of any medical conditions resulting from respirable crystalline silica exposure that require further examination or treatment.

4.6.8 The medical provider shall provide the following information to the employee:

4.6.8.1 A copy of the results of the medical examination, to include results of x-rays, spirometry and other laboratory testing, and

4.6.8.2 Any abnormalities, whether occupational or non-occupational, with recommendations, if any, for medical followup.

4.6.9 The employer shall provide the employee with a copy of the physician's written opinion within 30 days from its receipt. Situations of serious incidental disease or findings shall be reported to the employee as soon as feasible.

4.7 *Medical Protection:*

4.7.1 Workers with profusion of opacities equal to or greater than 1/1 shall be evaluated at a frequency as determined by a physician qualified in pulmonary disease. Recommendations provided by the examining physician regarding placement of the worker in the workplace will be followed for affected workers.

4.7.2 Workers with profusion of opacities equal to or greater than 1/1 will be counseled by a physician or other person qualified in occupational safety and health, at least annually, about silicosis prevention, safe work practices, respiratory

protection, personal habits, smoking cessation, and other items and areas that could contribute to the betterment of their respiratory health.

4.7.3 When silicosis is diagnosed, it should be considered a sentinel event and all aspects of exposure monitoring, engineering control, administrative control, and personal protection should be closely re-examined and improved, as necessary, to protect similarly exposed workers.

4.8 *Worker Training and Education:*

4.8.1 *Training*—The employer shall provide training for each worker exposed or potentially exposed to respirable crystalline silica dusts at any level of exposure, including supervisors. Training shall be provided at no cost to the worker.

4.8.2 *Frequency*—Training shall be provided as follows:

4.8.2.1 Annually for all current workers covered in 4.8.1,

4.8.2.2 Prior to the initial job assignment for new workers exposed to respirable crystalline silica dusts,

4.8.2.3 Whenever a worker is assigned to a new or unfamiliar task or operation involving respirable crystalline silica dust exposure, and

4.8.2.4 Whenever a worker demonstrates unsafe job performance which may result in increased respirable crystalline silica dust exposures.

4.8.3 *Content*—At a minimum, training shall consist of the following elements:

4.8.3.1 The content of this practice and its appendix,

4.8.3.2 The specific nature of operations which could result in exposures to respirable crystalline silica dust above the OEL,

4.8.3.3 An explanation of engineering, work practice, hygiene, administrative and personal protection equipment (PPE) controls used in each of the above operations to eliminate or reduce respirable crystalline silica dust exposures, and

4.8.3.4 The purpose and description of the exposure monitoring and medical surveillance programs and the medical protection program, including information concerning the following:

4.8.3.4.1

The purpose of silicosis diagnostic exam elements such as work histories, chest X-rays, lung function tests, and TB screening,

4.8.3.4.2

The adverse health effects associated with excessive exposures to respirable crystalline silica dusts including silicosis, tuberculosis, and the possible association with lung cancer, autoimmune disorders, chronic renal disease, and

4.8.3.4.3

The relationship between smoking and exposure to respirable crystalline silica dusts in producing silicosis.

4.8.3.5 The purpose, selection, fitting, use, cleaning, disinfection, inspection, repairs, storage, and limitations of respirators if they are used to supplement engineering, administrative, and work practice controls to reduce respirable crystalline silica dust exposures.

4.8.4 *Competency*—Prior to assignment to new or unfamiliar respirable crystalline silica dust-exposing tasks and operations, the employer shall ensure that workers demonstrate

proficiency in the use of all applicable exposure control measures for that operation such as PPE, engineering, administrative, work practice, and hygiene controls.

4.8.5 *Training Methods*—The employer shall present all training required by 4.8 in a language and manner that the worker is able to understand.

4.8.6 *Certification of Training*—The employer shall verify that training required by 4.8 has been completed by preparing a written certification record. The written certification record shall contain the name or other identity of the worker trained, the date(s) of the training, and the signature of the person who conducted the training or the signature of the employer. The most recent training certification shall be maintained.

4.8.7 *Access to Information and Training Materials*—The employer shall, upon request by any worker or their designated representative, permit review of this standard practice and its appendix, and to obtain copies of materials relating to the employer's silica training, medical, respiratory protection, and exposure control plan programs. Silica training materials protected by copyright, including but not limited to CD-ROMs and videos, are excluded from this requirement. If commercial materials are maintained at the work site, employees or their designated representatives shall be given the opportunity to review these materials.

4.8.8 Information concerning silicosis and other aspects of crystalline silica are available from OSHA, MSHA, and NIOSH.

4.9 *Warning Signs and Labels:*

4.9.1 In areas where respirable crystalline silica concentrations in the atmosphere are likely to exceed the standard, appropriate warning signs compatible with OSHA's (29 CFR 1910.1200) or MSHA's (30 CFR 47) Hazard Communication standards or state/local regulations/ordinances shall be provided. Warning signs, barricades, or work practices should be employed to restrict access to unauthorized persons. The method must alert anyone entering an exposure area as to the hazards and what actions or precautions should be taken. Examples of warning signs (English and Spanish) are provided (see [Appendix X3](#)).

4.9.2 A suitable warning label, in addition to or in combination with labels required by other statutes, regulations or ordinances shall be affixed to containers used for shipping material having a crystalline silica content that is capable of release which exceeds 0.1 % by weight or volume.

4.10 *Record Keeping:*

4.10.1 The employer shall establish and maintain an accurate record of all medical and exposure monitoring required by this practice. These records shall include, as a minimum, the following:

4.10.2 Name, identification number, and job classification of each worker monitored for dust exposure. The exposure monitoring result, work location, and monitoring date for each worker monitored, and the method for determining other workers whose exposure the measurement is intended to represent, and their identities. For sampling, see 4.2.11.

4.10.2.1 The type of respiratory protection worn by each worker monitored, if any, and fit testing records.

4.10.2.2 Where relevant, environmental variables that may have affected the measurement of worker exposure for each worker measurement.

4.10.3 Medical evaluation results and records of all sampling schedules, including sampling methods, analytical methods, breathing zone, and work area respirable crystalline silica dust concentrations shall be kept for at least 40 years or for the duration of employment plus 20 years, whichever is longer.

4.10.3.1 Medical records to include medical histories, radiographic films and any pulmonary function results shall be maintained according to standards of confidentiality and kept for at least 40 years or for the duration of employment plus 20 years, whichever is longer.

4.10.4 Each worker shall have access to records of that worker's occupational exposure and medical examination records and be able to make copies for their own use in accordance with regulatory provisions.

4.10.5 Employees will be informed of medical and sampling results within 30 days of receipt of this data, (also see 4.6.9). An acknowledgment record, signed by the employee, attesting to being so informed of his or her medical results, should be maintained along with medical records for at least 40 years or for the duration of employment plus 20 years, whichever is longer. Sampling history and medical records, with employee's consent and in accordance with standards of confidentiality, will be forwarded to their next employment if this employment is known.

4.11 *Evaluation of this Standard Practice:*

4.11.1 Periodic review and evaluation of workplace respirable silica exposure and silica-related health and disease records shall be performed to determine the effectiveness of control measures.

5. Physical and Chemical Properties

5.1 The physical and chemical properties of the crystalline silica (quartz) dusts and its polymorphs, cristobalite and tridymite, that are the subject of this practice vary over ranges characteristic of purity and particle size distribution.

5.1.1 Crystalline silica or quartz (CAS No 14808-60-7):

Specific gravity (20 C)	2.65
Melting point	1610 C
Boiling point	2230 C
Appearance	White to dark gray
X-Ray characteristics	Principal d-spacings and relative intensities 3.34 4.26 1.82

5.1.2 Cristobalite (CAS No. 14464-46-1):

Specific gravity (20 C)	2.33
Melting point	1713 C
Boiling point	2230 C
Appearance	White to yellowish
X-Ray characteristics	Principal d-spacings and relative intensities 4.05 2.48 2.84 3.13

5.1.3 Tridymite (CAS No. 15468-32-3):

Specific gravity (20 C)	2.26
Melting point	1703 C
Boiling point	2230 C
Appearance	White
X-Ray characteristics	Principal d-spacings and relative intensities 4.10 4.32 3.81 2.97

6. Laboratory Analysis

6.1 *General Requirements:*

6.1.1 The concentration of respirable crystalline silica dust in the air sampled with a gravimetric personal sampler shall be determined by NIOSH Methods 7500 (XRD), 7602 (IR), 7601 (visible absorption spectrophotometry) or 7603 (IR). Breathing zone sampling shall be as required in the method using a cyclone separator and the required filter. The employer shall ensure that the methods used to perform exposure monitoring produce results that are accurate to a confidence level of 95 %, and are within plus or minus 25 % for airborne concentrations of respirable crystalline silica above the 8-h TWA OEL. See **Appendix X1** for an sampling example.

NOTE 2—Each of the NIOSH methods include sections on applicability, interferences, accuracy, and evaluation. Generally, Method 7500 (XRD) is to be preferred, but recently there is increased use of Method 7602 (IR), particularly for coal mine dust samples. An advantage of Method 7500 is its ability to distinguish among quartz and cristobalite? and tridymite. Method 7601 does not distinguish among these three. Method 7602 (IR) can distinguish between quartz and cristobalite, but only at some loss of sensitivity. However, tridymite can be determined only in the absence of the other two polymorphs. Interferences should be considered when selecting an analytical method, especially when silicates are involved. To assist the laboratory in identifying interferences, information should be provided along with the sample concerning the potential presence of aluminum phosphate, feldspars, graphite, iron carbide, lead sulfate, micas, montmorillonite, potash, sillimanite, silver chloride, talc, and zircon.

7. Keywords

7.1 crystalline silica dust; cristobalite; dust; occupational exposure; permissible exposure limits; quartz dust; respirators; respiratory protection; tridymite

APPENDIXES**(Nonmandatory Information)****X1. RESPIRABLE SAMPLING TECHNIQUE**

X1.1 *Respirable Sampling*—Respirable dust samples can be collected using a two-stage, 10-mm nylon cyclone size-selective sampler that meets American Conference of Governmental Industrial Hygienists (ACGIH) criteria. The cyclone assembly is connected to a two-piece 37-mm cassette containing a collecting medium that consists of a pre-weighed 37-mm, low-ashing polyvinyl chloride (PVC) filter with a 5.0- μm pore size. A battery-operated pump, calibrated to a flow rate of 1.7

L of air per minute, will be used as the vacuum or pump source. For each day of sampling, one blank (unused) filter or a number equal to approximately 10 % of the total number of filters, all of the same lot, submitted for analysis, whichever is greater, should be sent to the laboratory. Sampling duration should be sufficient for laboratory detection at one-half the PEL at 5 % crystalline silica.

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Respirable-Dust/Silica Sampling Data Sheet

Location _____

Sample Number _____

Type of Sample:	<input type="checkbox"/> Personal breathing zone	<input type="checkbox"/> Work Area	<input type="checkbox"/> Other
If breathing-zone sample; was respirator used?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
Employee _____	Social Security No. _____		
Date of sample _____	Obtained by _____		
Description of job activity/work area: _____			

Weather conditions:	<input type="checkbox"/> Clear	<input type="checkbox"/> Overcast	<input type="checkbox"/> Rain/Snow	<input type="checkbox"/> Windy
Filter No. _____	Pump No. _____	Calibration date _____		
Time: _____	Start _____	Stop _____		
Rotameter reading (liters per minute): _____	Start _____	Stop _____		
Filter blank no. _____				
Average flow rate (liters per minute) x Duration of sample (minutes) x 0.001 = Volume of air sampled (cubic meters)				
_____ x _____ x 0.001 = _____				
Temperature _____ °C	Barometric Press _____ mmHg			
Air Volume Sampled (m ³) =	Pump Flow Rate	$\left[\frac{\text{liters}}{\text{min}} \right]$	$\left[\frac{\text{mmHg}}{^\circ\text{C}} \right]$	$\left[\frac{298}{760} \right]$
			$\left[\frac{\text{sampling min}}{\text{time}} \right]$	$\left[\frac{1}{1} \right]$
(0.001) = cubic meters				

Analytical Results:	
Respirable dust _____ (mg)	Respirable silica _____ (mg) or _____ (%)
Analytical method _____	Name of Lab _____
$\% \text{ Respirable silica} = \frac{\text{Respirable silica (milligrams)}}{\text{Respirable dust (milligrams)}} \times 100 = \text{_____} \%$	

Respirable dust concentration	=	$\frac{\text{Respirable dust (mg)}}{\text{Volume of air samples (m}^3\text{)}}$	=	$\frac{\text{mg}}{\text{m}^3}$
$\% \text{ Exposure} = \frac{\text{Respirable dust concentration}}{\text{Exposure Limit}} \times 100 = \text{_____} \%$				
Exposure Limit: 0.1 mg/m ³ for OSHA $\frac{10}{2 + \% \text{ Respirable silica}}$ mg/m ³ for MSHA				
(If result exceeds 100%, the exposure limit is exceeded)				
Mixtures:				
PEL = $\frac{10 \text{ mg/m}^3}{\% \text{ Respirable silica} + 2 (\% \text{ respirable cristobalite}) + 2 (\% \text{ respirable tridymite}) + 2}$				

Name of Person Conducting Sampling _____

Signature _____ Date Form Completed _____

FIG. X1.1 Sampling Data Sheet

Pump Calibration Record

Location _____ Pump Number _____

Date	Calibrated Flow Rate	Calibration Method	Sampling Location	Person Performing Calibration

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FIG. X1.2 Pump Calibration Record