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Standard Practice for Health Requirements Relating to Occupational Exposure to Respirable Crystalline Silica[1]

This standard is issued under the fixed designation E1132; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Appendix X1 editorially corrected in August 2013.

INTRODUCTION

Silicon dioxide (silica, SiO_2) 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 silica[2] 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 has been designated Practice E2625.

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 *Units*—The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.4 *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

E2625 Practice for Controlling Occupational Exposure to Respirable Crystalline Silica for Construction and Demolition Activities

2.2 *ANSI Standards:*[5]

ANSI/AIHA Z9.2 Fundamentals Governing the Design and Operation of Local Exhaust Systems

ANSI Z9.7

Z88.2 American National Standard Practice for Respiratory Protection

[1] This practice is under the jurisdiction of ASTM Committee E34 on Occupational Health and Safetyand is the direct responsibility of Subcommittee E34.80 on Industrial Heath.

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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.

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
29 CFR 1926.57 Ventilation
29 CFR 1926.103 Respiratory Protection
30 CFR 47, Hazard Communication
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
Guidelines for the Use of the ILO International Classification of Radiographs

2.5 *Other References:*
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/(% quartz + 2) 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/(% quartz + 2) 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):

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

NOTE 1—Federal OSHA PEL is approximately equivalent to a quartz level of 100 µg/m^3.

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: PEL = 10/(% quartz + 2) mg/m^3. The PEL for respirable cristobalite and tridymite is one-half the value for quartz.

4.1.3 Occupational Exposure Limits may vary country by country. Please consult the authority in the country, where the operation exists. Examples of other OELs are provided in Appendix X2.

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 Safety Data Sheets (SDS), 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 Where qualitative risk assessment indicates that a potential risk is present, initial sampling of tasks or 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 have the potential to be exposed to silica. Initial task sampling would be not required for short duration or transient tasks, tasks where sampling results would not be timely, representative concentrations are already known or proved task protection is in place. Conduct exposure sampling when needed to detect overexposures due to significant and deleterious change in the contaminant generation process or the exposure controls. This is particularly true for areas or operations where conditions can change dramatically within a short span of time.

4.2.3 Sampling strategy should follow good industrial hygiene practice.

4.2.4 Recordkeeping required under this practice shall be maintained and made available for review by employees and consistent with federal or state requirements.

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

[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.

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

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.

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.

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 or based on representative sampling data for defined tasks. Results used to establish sampling or protection plan, or both.
Sampling results are below OEL	No periodic sampling necessary but additional samples may be required due to process changes or new qualitative assessments.
No OEL overexposure found, but exposures exceed one-half the OEL.	These locations are to be included in a sampling plan. Sampling strategy may be determined by a qualitative assessment or statistical analysis that facilitates determination of the likelihood that exposures may sometimes exceed the OEL. If qualitative assessment or statistical analysis indicates exposures may sometimes exceed the OEL, see below.
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 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 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 the OEL.
Short duration (hours) silica dust generation operations such as drilling and cutting	Depend on task or 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.

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 information. 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 *Exposure Monitoring:*

4.3.1 The employer shall provide employees with an explanation of the sampling procedure.

4.3.2 Whenever exposure monitoring activities require 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 Sampled employees shall be provided with copies of their sampling results when returned by the laboratory and explanations of their 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.

NOTE 2—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 ANSI Z9.7 or federal and state requirements and consensus guidelines.

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

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 or used, or both, 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.

4.4.2.6 *Task-based Control Strategies*—Where exposure levels are known from empirical data, a task based control strategy can be applied that matches tasks with controls. The following lists examples of this approach.

(1) Abrasive Blasting—OSHA has already established standards for abrasive blasting work requiring ventilation (29 CFR 1926.57) and respiratory protection (29 CFR 1926.103). In the case of abrasive operations, it is recommended that the employer provide a Type CE, pressure demand or positive-pressure, abrasive blasting respirator (APF of 1000 or 2000).

4.4.3 *Work Practices and Administrative Controls:*

4.4.3.1 Ensure that workers do not work in areas of visible dust generated from materials known to contain more than 1 percent respirable crystalline silica 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 to the OEL or below.

4.4.4 Other engineering controls with the potential to limit exposure are:

(1) Wet suppression systems;

(2) Ventilation;

(3) Cutting Silica Containing Materials—The controls found in Tables 2-6, taken from Practice E2625, apply to employees cutting silica containing materials during a full work shift and do not apply to occasional cutting limited to 90-min total time;

(4) Tools designed to reduce dust; and

(5) Vacuum systems.

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 OEL. 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 shall comply with the requirements contained herein.

4.5.2 When respirators are required 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 7. All respirators must be approved for use against silica type dusts. Respirators must comply with requirements of ANSI Z88.2. See Table 7 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 respirators. The tests shall be used to select respirators that provide the required protection.

4.5.4 Where required by this practice, the employer shall institute a respiratory protection program that includes: individual medical clearance for respirator usage, worker training

TABLE 2 Cutting Masonry Units

Operation/Task	Control Measures	Respiratory Protection
Cutting masonry units— (Using stationary or portable saws)	*Wet Method*: Continuously apply stream or spray at the cutting point.	Not Required
	OR *Dry Method*: Enclose saw within a ventilated enclosure operated with a minimum face velocity of 250 feet-per-minute. Saw blade must be contained entirely within the booth and exhaust must be directed away from other workers or fed to a dust collector with a HEPA filtration system.	100 series filtering face piece (disposable dust mask) OR ½ face respirator with 100 series filters
* Additional control measures for consideration: Ventilation (natural and mechanical), dust collection methods, architectural design, use special-shaped products, job rotation and demarcation of specific cutting areas.		

TABLE 3 Mixing Concrete, Grout, and Mortar

Operation/Task	Control Measures	Respiratory Protection
Mixing Concrete, Grout or Mortar	Natural ventilation and demarcation of mixing areas	Not Required

TABLE 4 Tuck Pointing

NOTE 1—The following control measures have the potential to be useful in reducing exposure levels, but are not necessarily adequate to reliably reduce exposures below the PEL.

Operation/Task	Control Measures	Respiratory Protection
Tuck Pointing	The following control measures may be useful in reducing exposure levels but may not be adequate to reliably reduce exposures below the PEL. Ventilation Natural Mechanical Dust collection/vacuum Shroud Gauge/Guide for Equipment Wet methods	These types of respiratory protection will be necessary to provide adequate protection in the absence of control methods that demonstrate compliance with the PEL: Full face respirator with 100 series filter OR Supplied air respirator

TABLE 5 Concrete Cutting

Operation/Task	Control Measures	Respiratory Protection
Outdoor Slab Sawing	Use water-fed system that delivers water continuously at the cut point with natural ventilation OR Early entry sawing OR Dry cutting with integrated vacuum system	Not Required
Indoor Slab Sawing	Use water-fed system that delivers water continuously at the cut point with natural ventilation.	100 series filtering face piece respirator
	OR Mechanical ventilation (fans)	100 series filtering face piece respirator
	OR Early entry sawing OR Dry cutting with integrated vacuum system	100 series filtering face piece respirator
Outdoor Wire Sawing w/ remote Outdoor Wire Sawing w/o remote	Use water-fed system that delivers water continuously on wire, operated via remote control with natural ventilation.	Not Required
Outdoor Wall Sawing	Use water-fed system that delivers water continuously on blade with natural ventilation.	Not Required
Indoor Wall Sawing	Use water-fed system that delivers water continuously on blade, operated via remote control with natural ventilation.	100 series filtering face piece respirator
Outdoor Hand Sawing	Use water-fed system that delivers water continuously on blade with natural ventilation.	Not Required
	OR Use vacuum system at point of operation with natural ventilation.	Not Required
Indoor Hand Sawing	Use water-fed system that delivers water continuously on blade with natural ventilation.	100 series filtering face piece respirator

TABLE 6 Core Drilling

Operation/Task	Control Measures	Respiratory Protection
Core Drilling	Use water-fed system that delivers water continuously at the cut point with natural ventilation	Not Required
	OR *Dry Method*: Use vacuum system at point of operation with natural ventilation.	None OR 100 series filtering face piece respirators
Hand Held tools with core drilling bits	Use water-fed system that delivers water continuously at the cut point with natural ventilation.	None OR 100 series filtering face piece respirators
	OR Use vacuum system at point of operation with natural ventilation.	None OR 100 series filtering face piece respirators

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 required 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.

TABLE 7 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 operatorin 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.

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 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 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 for tuberculosis.

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 (FEV_1), and forced expiratory volume in 1 s as a percentage of total forced vital capacity (FEV_1/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 in accordance with federal and state requirements.

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:

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

(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

(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 *Documentation of Training*—The employer shall document that training has been completed in accordance with federal and state requirements.

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:*

4.9.1 In areas where respirable crystalline silica concentrations in the atmosphere are anticipated to exceed the OEL, appropriate warning signs shall be provided. Suggested signage may be found within the ANSI Z535 series.

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 3—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 Compliance Hierarchy

X1.1.1 Employers implement engineering controls and work practices to reduce and maintain employee exposures to or below the OEL.

X1.1.2 When feasible engineering or administrative controls and work practices are not sufficient to reduce employee exposure to or below the OEL, the employer supplements them with the use of respiratory protection in accordance with the requirements of OSHA's Respiratory Protection Standard, 29 CFR 1910.134 and 29 CFR 1926.103.

X1.2 Engineering Controls

X1.2.1 The use of properly designed engineering controls is generally thought to be the most reliable approach for controlling dust from crystalline silica-containing materials. The employer should review the work site to determine which, if any, engineering controls are technologically feasible for each project. The following are some of the engineering controls that can be used to control dust generation:

(1) Specialized tools that reduce dust generation;

(2) Natural ventilation;

(3) Local exhaust systems;

(4) Shrouds, HEPA filters, fans, ventilation systems, and other specialty equipment that can be used to suppress dust (such as cabs, enclosures, or isolation systems);

(5) Dust suppression systems;

(6) Dust collection systems; and

(7) Wet systems or methods.

X1.3 Work Practices or Administrative Controls

X1.3.1 The following are some of the work practices that can be used to control dust generation:

(1) A comprehensive hazard communication program, incorporating a silica-based training program with appropriate emphasis on silica hazards, silica-specific control measures, and compliance with instructions accompanying manufacturers' materials and equipment;

(2) Position the worker upwind of the work;

(3) Job rotation and creative scheduling; and

(4) The employee shall follow good personal hygiene and housekeeping practices which include:

(a) Not smoking tobacco products; use of tobacco products has been shown to increase the risk of illness from exposure to airborne crystalline silica;

(b) Avoiding, to the extent practical, activities that would contribute significantly to an employee's exposure to airborne respirable crystalline silica; and

(c) Prohibiting the use of compressed air to clean up respirable crystalline silica dust.

X1.4 Personal Protective Equipment (PPE)—General

X1.4.1 If engineering controls and administrative controls will not adequately protect the workers, personal protective equipment (PPE) should be evaluated for each work classification relative to an assessment of the site hazards.

X1.5 Implementation and Employee Compliance

X1.5.1 To have an effective exposure control program for crystalline silica, employers shall:

X1.5.1.1 establish work rules designed to ensure compliance with the applicable requirements;

X1.5.1.2 adequately communicate those work rules to its employees; and

X1.5.1.3 take effective actions to enforce the rules when violations are discovered.

X1.6 Determining Exposure

X1.6.1 A silica exposure assessment should include the following elements:

(1) A list of tasks the employees will perform, which may result in employee exposure to respirable crystalline silica;

(2) A list of engineering and administrative controls and necessary respiratory protection equipment used by the employer to reduce exposures to each task identified; and

(3) A determination that the measures used by the employer are adequate.

Respirable-Dust/Silica Sampling Data Sheet

Location _____ Sample Number _____

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

_____

Weather conditions: ☐ Clear ☐ Overcast ☐ Rain/Snow ☐ 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) × Duration of sample (minutes) × 0.001 = Volume of air sampled (cubic meters)
_____ × _____ × 0.001 = _____
Temperature _____ °C Barometric Press _____ mmHg

$$\text{Air Volume Sampled } (m^3) = \text{Pump Flow Rate} \left[\frac{\text{liters}}{\text{min}}\right] \left[\frac{\text{mmHg}}{\text{°C}}\right] \left[\frac{298}{760}\right] \left[\frac{\text{sampling time}}{1}\right] \frac{\text{min}}{(0.001)} = \text{cubic meters}$$

Analytical Results:
Respirable dust _____ (mg) Respirable silica _____ (mg) or _____ (%)
Analytical method _____ Name of Lab _____

$$\% \text{ Respirable silica} = \frac{\text{Respirable silica (milligrams)}}{\text{Respirable dust (milligrams)}} \times 100 = \_\_\_\_\_ \%$$

$$\text{Respirable dust concentration} = \frac{\text{Respirable dust (mg)}}{\text{Volume of air samples } (m^3)} = \frac{mg}{m^3}$$

$$\% \text{ Exposure} = \frac{\text{Respirable dust concentration}}{\text{Exposure Limit}} \times 100 = \_\_\_\_\_ \%$$

Exposure Limit: 0.1 mg/m³ for OSHA
$\frac{10}{2 + \% \text{ Respirable silica}}$ mg/m³ for MSHA

(If result exceeds 100%, the exposure limit is exceeded)

Mixtures:

$$\text{PEL} = \frac{10 \text{ mg/m}^3}{\% \text{ Respirable silica} + 2 (\% \text{ respirable cristobalite}) + 2 (\% \text{ respirable tridymite}) + 2}$$

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

FIG. X1.2 Pump Calibration Record

GUIDE FOR EMPLOYEE NOTIFICATION

OF

DUST SAMPLING RESULTS

This document provides notification guidelines for informing employees of dust sampling results. Notification is primarily directed at personal sample results; those samples collected by both government regulators and the company or its designated agent.

You are encouraged to report ALL sample results to affected employees, especially those sample results that exceed the Permissible Exposure Limit. Notification should be accomplished within 15 calendar days following receipt of personal dust sampling results.

The following paragraph constitutes guidelines for notification:

"The results of your dust sampling for [date] showed a result of [XXXXX mg/m^3]. The Exposure Limit is [XXXXX mg/m^3] and therefore your exposure was in excess of [or within] this limit, resulting in [ ] percent exposure. During the sampling period, your activity log indicated that you were doing [work activity description]. The following actions [for excessive exposures] are being investigated to help reduce future exposures to yourself [list actions]. Continue to wear your respirator. [This statement applies if the exposure exceeds the Exposure Limit or the company required respirator use exposure value]."

For documentation purposes the above notification should be delivered orally and in writing.

FIG. X1.3 Employee Notification

Respiratory System Medical and Work History

Respiratory occupational health screening examinations can only indicate the presence of a possible medical problem. Abnormal findings detected by screening must be confirmed and then referred for diagnostic studies to determine their relationship to occupational exposure and/or their true significance. An accurate and up-to-date medical and work history is an essential part of a health screening examination. Please answer the following questions as completely and frankly as you can. If you are uncertain of a response, write "don't know" or "unsure". Do not leave answers blank. Your answers will be held in strict confidence in your medical records and may be used in medical studies without public release of your name.

Name _____ Date of birth _____
Social Security no. _____ Home phone _____
Company name _____
Plant location _____
Job title _____
Physician's name _____ Physician's phone _____
Physician's address _____
City _____ State _____ Zip _____
Your height: _____ feet _____ inches
Race (optional): ☐ White ☐ Black ☐ Hispanic ☐ Asian/Pacific ☐ Alaskan/Indian
Sex: ☐ Male ☐ Female

Family History

Your family history plays a significant role in your medical health status. Please check the appropriate boxes to indicate if any member of your family has had any of the following conditions:

Respiratory problems, lung disorders:
☐ Father ☐ Mother ☐ Grandparent ☐ Brother/sister ☐ Children

Asthma, hay fever, allergies:
☐ Father ☐ Mother ☐ Grandparent ☐ Brother/sister ☐ Children

Emphysema or bronchitis:
☐ Father ☐ Mother ☐ Grandparent ☐ Brother/sister ☐ Children

Tuberculosis or consumption:
☐ Father ☐ Mother ☐ Grandparent ☐ Brother/sister ☐ Children

Lung or respiratory cancer:
☐ Father ☐ Mother ☐ Grandparent ☐ Brother/sister ☐ Children

Heart problems:
☐ Father ☐ Mother ☐ Grandparent ☐ Brother/sister ☐ Children

Collapsed lung:
☐ Father ☐ Mother ☐ Grandparent ☐ Brother/sister ☐ Children

FIG. X1.4 Respiratory System Medical and Work History

Respiratory System Medical and Work History

Personal History

How many colds have you had in the past year?
☐ 1–3 ☐ 4 or more

Do you cough up sputum/phlegm?
☐ After getting up in the morning ☐ When lying down ☐ All day

What color is your sputum/phlegm?
☐ White or clear ☐ Yellow or green ☐ Bloody

Have you ever had asthma?
☐ Yes ☐ Yes (currently under treatment) ☐ Childhood only

Do you have:
☐ Chronic or dry cough not due to cigarettes or smoking ☐ Chronic or recurrent productive cough
☐ Blood being coughed up from chest or lungs ☐ Red, rusty, or foaming pink phlegm

Do you usually cough first thing in the morning (on getting up) in the winter?
☐ Yes ☐ No

Do you usually cough during the day—or at night—in the winter?
☐ During the day ☐ At night ☐ At work

Do you cough like this on most days (or nights) for as much as three months each year?
☐ Yes ☐ No

Do you usually bring up any phlegm from your chest during the day—or night—in the winter?
☐ Yes ☐ No

In the past three years have you had a period of (increased) cough and phlegm lasting for three weeks or more?
☐ Yes ☐ No

Have you had more than one such period?
☐ Yes ☐ No

Have you coughed up blood:
☐ In the past year ☐ Before the past year

Are you troubled by shortness of breath:
☐ When hurrying on level ground or walking up a short hill ☐ When walking on level ground with people your own age
☐ During exercise ☐ At work

Does your chest ever sound wheezing or whistling?
☐ During the day ☐ At night

Have you recently had attacks of shortness of breath with wheezing?
☐ Yes, at home ☐ Yes, at work

If so, is your breathing absolutely normal between attacks?
☐ Yes ☐ No

What weather conditions affect your chest?
☐ Fog ☐ Damp ☐ Cold ☐ Heat

Do you usually have a stuffy nose in the winter?
☐ Yes ☐ No

FIG. X1.4 *(continued)*

Respiratory System Medical and Work History

Personal History (Continued)

Do you usually have a stuffy nose in the summer?

☐ Yes ☐ No

Do you have a stuffy nose for as much as three months each year?

☐ Yes ☐ No

During the past three years, has any chest illness kept you from your usual activities for as much as a week?

☐ Yes ☐ No

Did you bring up more phlegm than usual during any such illness?

☐ Yes ☐ No

Have you ever had:

☐ Chest injury	☐ Chest operation	☐ Heart trouble	☐ Bronchitis	☐ Pneumonia
☐ Pleurisy	☐ Pulmonary tuberculosis	☐ Bronchial asthma	☐ Emphysema	☐ Bronchiectasis
☐ Collapsed lung	☐ Black lung disease	☐ Asbestosis	☐ Pneumoconiosis	☐ Byssinosis
☐ Farmer's lung	☐ Other chest trouble			

Smoking history:

☐ Never smoked	☐ Ex-smoker	☐ Present smoker—do not inhale
☐ Present smoker—inhale slightly	☐ Present smoker—inhale moderately	☐ Present smoker—inhale deeply

Type of smoker:

☐ Cigarettes only ☐ Pipe only ☐ Cigars only ☐ Cigarettes, pipe and cigars ☐ Cigars and pipe

If you are an ex-smoker, how much did you smoke per day?

☐ ½ pack ☐ 1 pack ☐ 1½ packs ☐ 2 packs ☐ More than 2 packs

Do you use smokeless tobacco?

☐ Snuff ☐ Chewing tobacco

If you currently smoke, how much do you smoke per day (average, including weekends)?

Cigarettes:	☐ ½pack	☐ 1 pack	☐ 1½ packs	☐ 2 packs	☐ More than 2 packs
Cigars:	☐ 1	☐ 2-5	☐ 6-10	☐ 11 or more	
Pipe:	☐ ½ oz.	☐ 1 oz.	☐ 2 oz.	☐ More than 2 oz.	

What age were you when you started smoking?

_____ years

For how many years have you smoked?

_____ years

Have you ever worked:

☐ In dusty places	☐ In a coal mine	☐ In a hard rock or uranium mine
☐ In a mill processing mined or quarried materials	☐ In any other mine	☐ In a quarry, including sand
☐ In a foundry	☐ In a pottery	☐ In abrasive blasting/sand blasting
☐ In construction, insulation, or shipyard work	☐ In welding	☐ With asbestos
☐ With X-rays or radioactive substances		

FIG. X1.4 *(continued)*

Respiratory System Medical and Work History

Personal History (Continued)

Have you ever worked where you often or daily breathed any of the following materials? (Check all appropriate.)

☐ Coal dust	☐ Silica or blasting sand	☐ Asbestos dust	☐ Talc, clay, diatomaceous earth
☐ Insect or plant spray	☐ Metal fumes or dust	☐ Plastic or resin fumes	☐ Engine exhaust fumes
☐ Grain dust	☐ Wood dust	☐ Toxic or irritating gases	☐ Toluene diisocyanate
☐ Methyl isocyanate	☐ Other isocyanates	☐ Mold, spores, pollen, yeast, or fungi	☐ Lead

Do you have a fear of:

☐ Being in closed places ☐ Wearing a face mask or respirator

Have you ever been told by a physician not to wear a face mask:

☐ Yes ☐ No

Do you have a problem getting a face mask or respirator to fit properly because of:

☐ Facial configuration ☐ Facial hair

How often do you wear a respirator?

☐ 4–8 hours per day ☐ Less than 4 hours per day ☐ As needed ☐ For emergencies only

What are the conditions when you use a respirator?

☐ Normal ☐ Noisy ☐ Heavy physical work

Can you use a respirator comfortably?

☐ Yes ☐ No

Have you been trained in the proper use of a respirator?

☐ Yes ☐ No

Do you have any of the above following symptoms while at work?

☐ Coughing and wheezing ☐ Throat irritation ☐ Nose irritation ☐ Eye irritation

Do you have any of the above symptoms after work?

☐ At night ☐ On weekends

Have you ever been off work for a shift or longer after acute exposure to gases or fumes?

☐ Yes ☐ No

Comments

FIG. X1.4 *(continued)*

X2. TABLE OF OCCUPATIONAL EXPOSURE LIMIT VALUES

X2.1 The following table shows the Occupational Exposure Limits (OEL) in mg/m^3 for quartz, cristobalite and tridymite. OELs are expressed as 8-h time weighted average exposure limits for respirable particulate.

TABLE X2.1 Table of Occupational Exposure Limit Value

NOTE 1—OELs unless otherwise indicated are applicable to 100 % quartz, cristobalite, or tridymite.

Country	Note	Quartz (q)	Cristobalite (c)	Tridymite (t)
Australia	1	0.1	0.1	0.1
Austria	2	0.15	0.15	0.15
Belgium	3	0.1	0.05	0.05
Bulgaria	4	0.7	0.7	0.7
Canada-Ontario	5	0.1	0.05	
Canada-Quebec	6	0.1	0.05	0.05
Cyprus	7	10k/Q[A]		
Czech Republic	8	0.1	0.1	0.1
Denmark	9	0.1	0.05	0.05
Estonia	10	0.1	0.05	0.05
Finland	11	0.2	0.1	0.1
France	12	5 or 25/Q[B]		
	13	0.1	0.05	0.05
Germany	14	preventable strategy[C]		
Greece	15	0.1	0.05	0.05
Hungary	16	0.15	0.15	0.15
Ireland	17	0.05	0.05	0.05
Italy	18	0.025	0.025	0.025
Lithuania	19	0.1	0.05	0.05
Luxembourg	20	0.15	0.15	0.15
Netherlands	21	0.075	0.075	0.075
New Zealand	22	0.2	0.1	0.1
Norway	23	0.1	0.05	0.05
Poland	24	0.3	0.3	0.3
Portugal	25	0.025	0.025	0.025
Romania	26	0.1	0.05	0.05
Singapore	27	0.1	0.05	0.05
Slovakia	28	0.1	0.1	0.1
Slovenia	29	0.15	0.15	0.15
South Korea	30	0.05	0.05	0.05
Spain	31	0.1	0.05	0.05
Sweden	32	0.1	0.05	0.05
Switzerland	33	0.15	0.15	0.15
United Kingdom	34	0.1	0.1	0.1
USA (OSHA)	35	10/(% SiO_2 + 2)	PEL (Quartz)/2	PEL (Quartz)/2
USA (MSHA)	36	10/(% SiO_2 + 2)	PEL (Quartz)/2	PEL (Quartz)/2
USA (NIOSH)	37	0.05	0.05	0.05

[A]Q: quartz percentage – k=1

[B]OEL is 5 mg/m^3 for dust with <5 % quartz and is 25 mg/m^3/%Quartz for dust >5 % quartz. Q: quartz percentage.

[C]Germany has no more OEL for quartz, cristobalite, tridymite. Employers are obliged to minimize exposure as much as possible and to follow certain protective measures.

Note	Country	Occupational Exposure Limit (OEL) Name	Adopted by	Updated	Source
1	Australia	Workplace Exposure Standard	Worksafe Australia	4/12	http://www.safeworkaustralia.gov.au
2	Austria	Maximalen ArbeitsplatzKoncentration	Bundesministerium fur Arbeit und Soziales	5/10	IMA-Europe[A]
3	Belgium		Ministere de l'Emploi et du Travail	5/10	IMA-Europe[A]
4	Bulgaria	Limit values	Ministry of Labour and Social Policy and Ministry of Health. Ordinance n°13 of 30/12/2003	5/10	IMA-Europe[A]
5	Canada-Ontario	Occupational Exposure Limit	Ontario Ministry of Labour	1/13	http://www.labour.gov.on.ca/english/hs/pubs/oel_table.php
6	Canada-Quebec	Permissible Exposure Value		4/13	http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=3&file=/S_2_1/S2_1R13_A.HTM
7	Cyprus		Department of Labour Inspection. Control of factory atmosphere and dangerous substances in factories, Regulations of 1981.	5/10	IMA-Europe[A]

8	Czech Republic		Governmental Directive n°441/2004	5/10	IMA-Europe[A]
9	Denmark	Threshold Limit Value	Direktoratet fot Arbeidstilsynet	5/10	IMA-Europe[A]
10	Estonia			5/10	IMA-Europe[A]
11	Finland	Occupational Exposure Standard	National Board of Labour Protection	5/10	IMA-Europe[A]
12	France	Empoussierage de reference	Ministere de l'Industrie (RGIE) [for mines and quarries]	5/10	IMA-Europe[A]
13		Valeur limite de Moyenne d'Exposition	Ministere du Travail [for all workplaces except mines and quarries]	5/10	IMA-Europe[A]
14	Germany	Maximalen ArbeitsplatzKoncentration	Bundesministerium für Arbeit	5/10	IMA-Europe[A]
15	Greece		Legislation for mining activities	5/10	IMA-Europe[A]
16	Hungary			5/10 10/12	IMA-Europe[A] (crisbobalite from IFA – GESTIS http://limitvalue.ifa.dguv.de/WebForm_ueliste.aspx)
17	Ireland		2002 Code of Practice for the Safety, Health & Welfare at Work (CoP)	5/10	IMA-Europe[A]
18	Italy	Threshold Limit Value (based on ACGIH TLVs)	Associazone Italiana Degli Igienisti Industrial	5/10	IMA-Europe[A]
19	Lithuania	Ilgalaikio poveikio ribiné verté (IPRV)	DI Lietuvos higienos normos HN 23:2001	5/10	IMA-Europe[A]
20	Luxembourg	Maximalen ArbeitsplatzKoncentration	Bundesministerium für Arbeit	5/10	IMA-Europe[A]
21	Netherlands	Publieke grenswaarden http://www.ser.nl/en/oel_database.aspx	Ministerie van Sociale Zaken en Werkgelegenheid	5/10	IMA-Europe[A]
22	New Zealand	Workplace Exposure Standard	Ministry of Business, Innovation and Employment	2/13	http://www.osh.govt.nz/order/catalogue/329.shtml
23	Norway	Administrative Normer (8hTWA) for Forurensing I ArbeidsmiljØet	Direktoratet for Arbeidstilsynet	5/10	IMA-Europe[A]
24	Poland				IMA-Europe[A]
25	Portugal	Valores Limite de Exposição (VLE)	Instituto Portuges da Qualidade, Hygiene & Safety at Workplace NP1796:2004	5/10	IMA-Europe[A]
26	Romania	OEL	Government Decision n° 1093/2006 regarding carcinogenic agents (in Annex 3: Quartz, Cristobalite Tridymite).	5/10	IMA-Europe[A]
27	Singapore	Permissible Exposure Level	Ministry of manpower	1/13	http://statutes.agc.gov.sg/aol/search/display/view.w3p;page=0;query=DocId%3A%22243a4769-0c31-4064-9949-e55994cff25c%22%20Status%3Apublished%20Depth%3A0;rec=0
28	Slovakia			5/10	IMA-Europe[A]
29	Slovenia			5/10	IMA-Europe[A]
30	South Korea	Occupational exposure limit	Ministry of Labor	10/12	IFA – GESTIS http://limitvalue.ifa.dguv.de/WebForm_ueliste.aspx
31	Spain	Valores Limites	Instrucciones de Tecnicas Complementarias (ITC) Orden ITC/2585/2007	5/10	IMA-Europe[A]
32	Sweden	Yrkeshygieniska Gränsvärden	National Board of Occupational Safety and Health	5/10	IMA-Europe[A]
33	Switzerland	Valeur limite de Moyenne d'Exposition		5/10	IMA-Europe[A]
34	United Kingdom	Workplace Exposure Limit	Health & Safety Executive	5/10	IMA-Europe[A]
35	USA OSHA	Permissible Exposure Limit (PEL)	Occupational Safety & Health Administration (OSHA)	4/13	29 CFR 1910.1000
36	USA MSHA	Permissible Exposure Limit (PEL)	Mine Safety and Health Administration (MSHA)	4/13	30 CFR 57.5001
37	USA NIOSH	Recommended Exposure Level (REL)	National Institute for Occupational Safety and Health (NIOSH)	4/13	http://www.cdc.gov/niosh/npg/npgd0684.html

[A]IMA-Europe. Date: May 2010, http://www.ima-europe.eu/sites/ima-europe.eu/files/publications/OEL_TABLE_Dust-QCT_May_2010_Jan09.pdf. Updated version available at http://www.ima-europe.eu/library/publications (keyword dust).