Designation: E1132 – 21

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.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

D4532 Test Method for Respirable Dust in Workplace Atmospheres Using Cyclone Samplers

E1542 Terminology Relating to Occupational Health and Safety

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 Ventilation Systems

ANSI Z9.7 Recirculation of Air from Industrial Process Exhaust Systems

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

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[2] Smith, D. 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.

***A Summary of Changes section appears at the end of this standard**

ANSI 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

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. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this practice, refer to Terminology E1542.

4. Significance and Use

4.1 These practices and criteria were developed for occupational exposures. They are intended to (*1*) protect against clinical disease from exposure to respirable crystalline silica, (*2*) be measurable by techniques that are valid, reproducible, and readily available, and (*3*) be attainable with existing technology and protective practices.

5. General Requirements

5.1 *Occupational Exposure Limits (OELs):*

5.1.1 *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.

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

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

5.1.1.2 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.

5.1.2 *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 work week 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.

5.1.3 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.

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

5.2 *Exposure Assessment and Monitoring:*

5.2.1 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.

5.2.2 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 5.1, 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.

5.2.3 Sampling strategy should follow good industrial hygiene practice.

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

5.2.5 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.

[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.

5.2.6 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.

5.2.7 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 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 5.2.6)	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.

5.2.8 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.

5.2.9 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.

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

5.2.11 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.

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

5.3 *Exposure Monitoring:*

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

5.3.2 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.

5.3.3 Sampled employees shall be provided with copies of their sampling results when returned by the laboratory and explanations of their data.

5.4 *Methods of Compliance:*

5.4.1 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.

5.4.2 *Engineering Controls:*

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

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

5.4.2.3 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.