Module 19: Silica Exposure

Page 424-438

- Page 424-438

Page 424-438

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Module Description

OSHA estimates 2.3 million American workers are exposed to respirable crystalline silica within their job site or manufacturing plant. Over 80% of the workers that are exposed to silica dust are in the construction industry. Crystalline Silica has been linked to several medical conditions and even death to workers exposed to the deadly dust. Exposure to respirable crystalline silica is a health concern for exposed workers. The Occupational Safety and Health Administration (OSHA) recently updated the silica standard to increase the protection of workers through:

- Exposure identification sampling
- Medical evaluations
- Continued medical surveillance
- Lower Permissible Exposure Limit (PEL)
- Specific guideline for common construction tasks
- Requiring a silica exposure control program
- Addressing appropriate hazard exposure control

Module Learning Objectives

At the conclusion of this module, you should be able to:

- Identify materials which contain silica
- Understand the health hazards of respirable crystalline silica
- Explain the OSHA regulation on respirable crystalline silica for construction
- Be informed of the key provisions of the OSHA Construction standard 29 CFR 1926.1153
- Describe the federal guidance for medical surveillance
- Analyze exposure control techniques to protecting general industry workers from silica exposure
- Recognize the health hazards related to over exposure to respirable crystalline silica
- Identify the cause of lung tissue damage
- Understand the three major development stages of silicosis
- Explain the basic symptoms of silicosis

Lesson 1: The Issue

Lesson Focus

This lesson focuses on the following topics:

- Silica
- Over Exposure of Silica
- Silica Exposure Limits
- Exposure Assessment Options
- Exposure Control Options
- Requirements
- Hazard Communication
- Housekeeping

Silica

Silica molecule is made up of two of the most abundant elements on the earth, oxygen and silicon. The structure of a silica molecule is two Oxygen atoms to one Silicon atom. The bonded molecules when lined up in a repeatable pattern is referred to as “crystalline silica”. There are 3 identified forms of silica in the OSHA standard:

- Quartz
- Cristobalite
- Tridymite

Respirable crystalline silica dust is a very small particle of hazardous dust that is linked to lung cancer, silicosis, chronic obstructive pulmonary disease and kidney disease if breathed into the body. It is defined as Quartz, Cristobalite, and/or Tridymite material that is entrapped in airborne particles as defined by the sampling specifications of the International Organization for Standardization (ISO) 7708: 1995 Air Quality-Particle Size Fraction Definitions for Health-Related Sampling.

The source of the silica dust is from drilling, crushing, cutting, or grinding rocks such as quartz (the most common surface material by volume to make up the earth’s crust). However, silica can be found in brick, mortar, concrete, slate, granite, tile, sand-blasting sand, and filter media.

Silicosis is a lung disease that is related to silica exposure for workers that have chronic exposure or even acute exposures at a very high level of silica. Workers that develop

silicosis have such lung damage that they experience shortness of breath, occasional bluish skin at the ear lobes or lips, chronic fatigue, and loss of appetite.

Over Exposure of Silica

Over-exposure to respirable crystalline silica has been linked to several health diseases and conditions, such as, but not limited to:

- Lung Cancer
- Chronic Obstructive Pulmonary Disease (COPD)
- Chronic Kidney Disease (CKD)
- Silicosis

Lung Cancer is the leading cause of cancer death in America among, both men and women. When silica is inhaled along with smoking, there is a higher risk for workers to get lung cancer than either factor alone. The American Cancer Society reports, over 100 studies conducted have shown there is "strong consistent evidence that silica exposure increases lung cancer risks (American Cancer Society, 2013).

Chronic Obstructive Pulmonary Disease is a progressive and mostly irreversible airflow obstruction condition which afflicts mostly cigarette smoker. However a report done in the United Kingdom identifies the relationship of increased cases of COPD in non-smoking individuals that are exposed to silica at work (British Medical Bulletin, 2012).

Chronic Kidney Disease (CKD) is liked to workers that have occupational exposure to silica. Though the sample size is small, the US National Library of Medicine National Institutes of Health noted in a 2011 report that there is "a positive relationship between occupational silica exposure and CKD" (NCBI, 2011). Additionally, the report states exposure to silica may also be associated with earlier stages of kidney disease.

Silicosis is caused due to Silica exposure. It is a pulmonary disease that causes chronic inflammatory reaction. This disease is known to kill lung tissue due to the process where the body's immune response cells, the Macrophage, try to dissolve the silica dust. Instead, the macrophage become weighted down with the respirable crystalline silica and sink into the lung tissue where they die. The alveoli (air sacs) in the lungs are damaged as scarred because of the activity that caused the macrophage to die. Eventually, the worker will have difficulty breathing and die from the exposure to silica.

There are 3 major development stages for the development of silicosis:

1. **Chronic** (> 10 years of mild over-exposure of respirable crystalline silica)
2. **Accelerated** (5-10 years of moderate over-exposure of respirable crystalline silica)
3. **Acute** (weeks-3 years of heavy over-exposure of respirable crystalline silica)

Basic symptoms of silicosis are as follows:

- Fever
- Loss of appetite
- Fatigue
- Occasional blue hues skin at ear lobes or lips
- Shortness of breath while exercising
- Persistent coughing

Workers that have silica exposure and exhibit signs for silicosis should seek medical attention.

Silica Exposure Limits

Exposure Limits and Specific Construction Task Identified in Task 1 of the Standard

The Occupational Safety and Health Administration (OSHA) has revised its Silica standard to reflect the current research which showed the previous standard wasn't protective enough for workers. The new regulation is expressed in the amount of silica that a worker can be exposed over an 8-hour time weighted average (TWA). This limit is called the Permissible Exposure Limit (PEL) and it has been lowered to 50 micrograms of respirable crystalline silica per cubic meter of air (µg/m3). At the 25 µg/m3 averaged over an 8-hour day level the employer must act to reduce the exposure to the worker.

The employer must prove that a workplace that is presumed or known to have over 25 µg/m3 (Action Level) over a Time Weighted Average (TWA) of a course of an 8-hour work shift, has been assessed. OSHA's Permissible Exposure Limit (PEL) for silica exposure is 50 µg/m3 over a TWA of an 8-hour period.

To calculate the TWA for exposure the employer must use the following calculation:

TWA= (Ca Ta + Cb Tb……Cn Tn)/8

TWA is the exposure for the work shift

C is the concentration during any period of Time (T) where the concentration of the silica is constant; and the Time duration is expressed in hours at the noted concentration.

Example:

- 3 hours at 100 µg/m3
- 2 hours at 10 µg/m3
- 5 hours at 50 µg/m3

TWA= (3 x 100 + 2 x 10 + 5 x 50)/8= 71.25 µg/m3

This is above the action level and above the PEL; the employer must comply with the 29 CFR 190.1053 rules.

If construction workers do certain tasks as identified on the 29 CFR 1926.1153 Table 1 jobs, then the controls must be fully and properly implemented. The conditions for compliance of the specific controls under Table 1 are as follows:

- Using equipment as intended with engineering controls
- Maintaining equipment properly
- Teaching workers how to use equipment as instructed by the manufacturer
- Changing vacuum bags when needed
- Meant to help the construction employers to meet the regulations easily

Workers that are actively operating the listed equipment or have some responsibility for completing the task on Table 1 are called the “Engaged Employee”. However, non-engaged employees are the workers that are in the area of the regulated task. Additionally, worksites must have provisions to keep all workers and the general public from being exposed to silica dust exposure.

The list of tasks which uses equipment to create respirable crystalline are as follows (OSHA, 2018):

1. **Stationary masonry saws**
    a. Use a saw that is equipped with integrated water delivery system with constant feed
    b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
    c. No respiratory protection needed
2. **Handheld power saw (any diameter)**
    a. Use a saw that is equipped with integrated water delivery system with constant feed
    b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions.
    c. When used outdoors for:
        i. Less than 4 hours/shift no respirator is needed
        ii. More than 4 hours/shift respirator with a minimum assigned protection factor (APF) of 10
    d. When used indoors or enclosed areas
        i. Less than 4 hours/shift Respirator with APF 10
        ii. More than 4 hours/shift Respirator with APF 10
3. **Handheld power saws for cutting fiber-cement board (with blade diameter of 8" or less**
    a. Use saw equipped with commercially available dust collection system
    b. Use as outlined in O & M
    c. 99% or greater dust collection efficiency
    d. No respiratory protection needed
4. **Walk-behind saws**
    a. Use a saw that is equipped with integrated water delivery system with constant feed
    b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
    c. No respiratory protection needed
    d. When used outdoors for:
        i. Less than 4 hours/shift no respirator is needed
        ii. More than 4 hours/shift respirator no respirator is needed
    e. When used indoors or enclosed areas
        i. Less than 4 hours/shift Respirator with APF 10
        ii. More than 4 hours/shift Respirator with APF 10

5. **Drivable saws**
    a. Use a saw that is equipped with integrated water delivery system with constant feed
    b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
    c. No respiratory protection needed
6. **Rig-mounted core saws or drills**
    a. Use a saw that is equipped with integrated water delivery system with constant feed
    b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
    c. No respiratory protection needed
7. **Handheld and stand-mounted drills (including impact and rotary hammer drills**
    a. Use a saw that is equipped with shroud or cowling with dust collection
    b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
    c. Use a Hepa-filtered vacuum when cleaning holes
    d. Dust collector must be provided with a filter with 99% or greater efficiency and a filter-cleaning mechanism
    e. No protection needed
8. **Dowel drilling for concrete**
    a. Use shroud around drill bit with a dust collection system
    b. Dust collector must have a filter with 99% or greater efficiency and a filter-cleaning mechanism
    c. Use a HEPA-filtered vacuum when cleaning holes
    d. Work under 4 hours/shift use a respirator with an APF 10
    e. Work over 4 hours/shift use a respirator with an APF 10
9. **Vehicle-mounted drilling rigs for rock and concrete**
    a. Use dust collection system with close capture hood or shroud around drill bit with a low-flow water spray to wet the dust at the discharge point form the dust collector or,
    b. Operate from within an enclosed cab and use water for dust suppression on drill bit
    c. No respiratory protection needed
10. **Jackhammers and handheld powered chipping tools**
    a. Use tool with continuous stream or spray of water at point of impact or,
    b. Use tool with commercially available shroud and dust collection system
    c. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions

d. Dust collector must be provided with a filter with 99% or greater efficiency and a filter-cleaning mechanism
e. When used outdoors for:
    i. Less than 4 hours/shift no respirator is needed
    ii. More than 4 hours/shift respirator with a minimum assigned protection factor (APF) of 10
f. When used indoors or enclosed areas
    i. Less than 4 hours/shift Respirator with APF 10
    ii. More than 4 hours/shift Respirator with APF 10

11. Handheld grinders for mortar removal (i.e., tuckpointing)

a. Use grinder equipped with commercially available shroud and dust collection system
b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
c. Dust collector must provide 25 cubic feet per minute (cfm) or greater of airflow per inch of wheel diameter
d. Filter with 99% or greater efficiency and a cyclonic pre-separator or filter-cleaning mechanism
e. Work less than 4 hours/shift use respirator with an APF 10
f. Work more than 4 hours/shift use respirator with an APF 25

12. Handheld grinders for uses other than mortar removal

a. Use a saw that is equipped with integrated water delivery system with constant feed to the grinding surface
b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
c. No respiratory protection needed or,
d. Use grinder equipped with commercially available shroud and dust collection system
e. Dust collector must provide 25 cubic feet per minute (cfm) or greater of airflow per inch of wheel diameter
f. Filter with 99% or greater efficiency and a cyclonic pre-separator or filter-cleaning mechanism
g. When used outdoors for:
    i. Less than 4 hours/shift no respirator is needed
    ii. More than 4 hours/shift no respirator is needed
h. When used indoors or enclosed areas
    i. Less than 4 hours/shift no respirator is needed
    ii. More than 4 hours/shift Respirator with APF 10

13. **Walk-behind milling machines and floor grinders**
    a. Use a saw that is equipped with integrated water delivery system with constant feed to the cutting surface
    b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
    c. No respiratory protection needed or,
    d. Use a Hepa-filtered vacuum when used indoors or enclosed areas to remove loose dust in between passes
    e. Dust collector must be provided with a filter with 99% or greater efficiency and a filter-cleaning mechanism
    f. No respiratory protection needed
14. **Small drivable milling machines (less than half-lane)**
    a. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
    b. Use a machine equipped with supplemental water sprays designed to suppress dust. Water must be combined with a surfactant
    c. No respiratory protection needed
15. **Large drivable milling machine (half-lane and lager)**
    a. Asphalt Only at any depth
    b. Use machine with exhaust ventilation on drum enclosure and supplemental water sprays designed to suppress dust
    c. Cuts 4" in depth or less on any substrate
    d. Use machine with exhaust ventilation on drum enclosure and supplemental water sprays designed to suppress dust
    e. Operate and maintain machine to minimize dust emissions or,
    f. Use a machine with supplemental water spray designed to suppress dust. Water must be combined with a surfactant
16. **Crushing machines**
    a. Use equipment that is designed to spray or mist for dust suppression at crusher and other points where dust is generated
    b. Operate per the Operations and Maintenance (O & M) manual to minimize dust emissions
    c. Use a ventilated booth that provides fresh, climate-controlled air to the operator, or a remote-control station
    d. No respiratory protection needed
17. **Heavy equipment and utility vehicles used to abrade or fracture silica-containing materials**
    a. Operate equipment in an enclosed cab
    b. When employees outside of the cab are engaged in the task, apply water and/or dust suppressants as necessary to minimize dust emissions

18. **Heavy equipment and utility vehicles for tasks such as grading and excavating**
    a. Apply water and/or dust suppression as necessary to minimize dust emissions
    b. When the equipment operator is the only employee engaged in the task, operate equipment from within an enclosed cab

Exposure Assessment Options

Employers that either do not perform Table 1 tasks or choose to use another form of exposure control must evaluate the worksite for silica exposure. For the employer to know the actual employee exposure level to respirable crystalline silica, they will have to do worksite assessment. There are two options of assessments allowed under the silica standard:

- Performance option, or
- Scheduled monitoring option

Performance Option

Performance Option is the most flexible of the two accepted assessment methods. *Objective data* and/or *air monitoring data*, in any combination, is utilized to profile the work environment. *Air monitoring* must be done in accordance to the Appendix A of the standard. Appendix A lists laboratory procedures for measuring the quality of air. The statement of the approved laboratory as to the level of silica at the most representative location of the worker's environment is acceptable to OSHA.

Objective Data is information that is taken from sources such as, but not limited to,

- an employer,
- manufacturer,
- industry-wide surveys, or
- associations

This data must be an accurate depiction of the working conditions of the worksite in concentration, duration, types of materials, environmental conditions, etc. OSHA give examples of acceptable sources for objective data (OSHA, 2018):

- Calculations based on substance composition
- Area sampling exposure mapping based on results
- Historical data for air monitoring by the employer

- Air monitoring data that reflects the workplace from industry-wide surveys

If the employer chooses to use the performance option, then the following must occur:

- Exposure assessment must be done prior to the commencement or assignment of work
- Reassessment of exposure must be done if there is a change in the process, product, or hazard control equipment that is expected to increase the exposure
- The employer must prove that the assessment was accurate
- The employer must ensure that the exposure assessment reflects the exposure for each job classification and every shift.

Scheduling Monitoring Option

Scheduling monitoring option is an assessment method is performed as soon as work is set to begin. The exposed employee is given an air sampling device to wear at their breathing zone for a full shift. Another technique for conducting a scheduling monitoring is using a stationary air sampling meter which is positioned in a place that represents the highest concentrations of silica exposure for several employees in a regulated area.

The employer can discontinue monitoring if the initial employee monitoring is below the action level. If the most recent sampling event is at or above the action level, but below the PEL, then the sampling must be repeated within a 6-month period. However, if the most recent monitoring sampling reveals exposure above the PEL, then it must be repeated within 3 months.

Where the most recent, non-initial, exposure monitoring reveals that the sampling results are below the action level, then the employer needs 2 consecutive samples below the action level. The samples must be taken 7 or more days apart from each other. If one of the 2 follow up samples exceed the action level, then the employer must follow the procedures as outlined in the Reassessment of exposures section of the standard.

Employees must be notified, in writing or by a posting in a location where everyone can see, of the results of the silica exposure test results within 5 working days after the completion of either exposure assessment. The 5-day notification begins when:

- An employer receives the laboratory results of the scheduling monitoring test, or
- Following the completion of the performance option exposure assessment

Employees or the designated representative must be allowed to observe the air monitoring if requested. Anyone observing a scheduled monitoring assessment must be protected from silica exposure by engineering controls or personal protective equipment.

Exposure Control Options

Engineering controls are the most effective way to protect a worker from any hazard that cannot be eliminated. An engineering control is a physical device that will mitigate the hazard from encountering the worker. The second-best way to protect a worker from a hazard is to define administrative controls (work rules). Finally, Personal Protective Equipment (PPE) is utilized as the other two controls are being developed or the hazard is still present in some form after the other two controls.

Here are some examples of each type of control.

1. **Engineering Controls**
    a. Ventilation systems in cabs of vehicles
    b. Wet cutting methods
    c. Vacuums equipped with a 0.3-micron Hepa filter
2. **Administrative Controls**
    a. Policies and Procedures
    b. Following Operations and Maintenance (O & M) manuals
    c. Conducting Job Hazard Analysis (JHA)
    d. Exposure Control Plan
3. **Personal Protective Equipment (PPE)**
    a. Hand protection
    b. Eye and face protection
    c. Respiratory protection
    d. Gloves

Abrasive Blasting

Abrasive Blasting with substrates containing silica is regulated as an extremely high hazard task. The employer must comply with the Ventilation standard 1926.57. Additionally, it is encouraged to use alternative substrates to replace silica as an engineering control. The use of a respirator is mandatory when doing repair task where engineering and work practices aren't feasible.

Another requirement in this standard is to have a *written exposure control plan* which includes the following as a minimum:

- Description of the tasks in the workplace involving exposure to silica
- Description of engineering controls, work practices, and respiratory protection for each task
- Description of housekeeping measures
- Description of the signs that indicate the engineering or other exposure controls are not working effectively, such as increase of visible dust or no water being delivered on the blade of a handsaw
- Include manufacturer instruction for all tools and equipment that are being used per the Table 1 guidelines
- Annual review of plan for effectiveness and update the plan when necessary
- Written plan must be readily available to each employee covered by the section, their designated representative, the Assistant Secretary and the Director

Medical evaluation

Medical evaluation is another requirement for workers that are required to wear respirators under the standard for 30 or more days a year. The examinations must be offered every 3 years and must contain tests for pulmonary functions, chest x-ray, and a physical exam.

Medical surveillance is intended to:

1. Identify if there is any disease caused from exposure to respirable crystalline silica contracted by the worker and take actions to protect their health;
2. Determine if the work has any conditions that may make them or sensitive to working around silica;
3. Determine if the worker is fit to wear a respirator

After the exam the worker will get a report detailing their health and the employer will receive a medical opinion as per the limitations, if any, to the worker as a result of the exam. All medical evaluations must be free to the employees and offered at a reasonable time and place for the employee.

Additionally, medical records must be retained and available in accordance to 29 CFR 1910.1020 (must commonly regulated as the time of employment plus 30 years). The records must include:

- Air monitoring data
- Objective data
- Medical Records

Though silica sand in the respirable state can be very dangerous for the workers, it is controllable by engineering, administrative, and PPE. In some cases, the exposure to this dust can be eliminated by substitution methods. However, the employer must protect its workers from this known hazard through the methods outlined in the OSHA standard.

Hazard Communication

Employers must comply with the 29 CFR 1910.1200 Subpart Z hazard communication standard. This standard is commonly referred to as “the right to know” rule for chemical exposure. Workers must be aware of the hazards related to the handling, storage, and use of chemicals in or around their work environment. Under the silica standard employers must address:

- Cancer hazards
- Lung effects
- Immune system effects
- Kidney effects

Under the hazard communication standard each component of the facility must have:

- Labelling of primary and secondary containment of chemicals,
- A written hazard communication program
- An administer of the hazard communication program
- Training on the chemicals that the workers are exposed to the workplace
- Understanding of how to interpret the Safety Data Sheets (SDS)
- Knowledge of what task will produce over exposure to chemicals

Workers must be trained on the following topics regarding respirable silica dust exposure:

1. How the presence or release of silica is detected and analyzed
    - Objective data or Air Monitoring Sampling
2. To recognize that visible increase in dust concentration indicates that the work exposure control practice in inadequate
3. On the details of workplace-specific SDS information, signage, container labels, emergency procedures, written exposure control plan
4. Work practices that will reduce or increase the exposure to silica dust

5. Housekeeping techniques designed to reduce or eliminate the workplace exposure to silica

Workers must be retrained at the time that it is found that they are working in a manner that suggest that they have forgotten the initial training of the hazards of silica.

Acceptable training methods are as follows, but not limited to:

- Hands-on training
- Webinars
- Videotapes
- Slide presentations
- Classroom instruction
- Seminars
- Written material
- Any combination of training delivery systems

Housekeeping

Housekeeping is a term that refers to the condition of the work environment as a measure of cleanliness. Employees must avoid dry sweeping, brushing, or using compressed air to blow dust off of themselves or any surface. This practice will increase the exposure of silica to the worker and the surrounding workstations.

Alternatively, the employer must instruct workers to use:

- Wet cutting methods
- Collect dust in a 0.3-micron High Efficiency Particulate Arrestance (HEPA)Filter
- Compressed air cleaning only when used with a ventilation system that effectively captures the dust cloud

Lesson Summary

Exposure to silica has been linked to lung cancer, silicosis, chronic obstructive pulmonary disease, and kidney disease in workers. OSHA's silica standard aims to reduce this hazard through a detailed standard, training, and enforcement. Through the use of engineering controls, administrative controls, and PPE, the exposed worker can be protected from the harmful respirable crystalline silica dust.